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SUSQUEHANNA RIVER BASIN: A PLAN FOR CLEAN WATER
VOLUME II

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
WASHINGTON, D. C.

1969

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SUSQUEHANNA RIVER BASIN

A Plan for Clean Water

Vol. II

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This volume of the Susquehanna River Basin study contains details related to the middle Susquehanna sub-basin, the west branch Susquehanna River sub-basin, the Juniata sub-basin, and the lower Susquehanna sub-basin. Special needs, problems, and solutions within each sub-basin are described.

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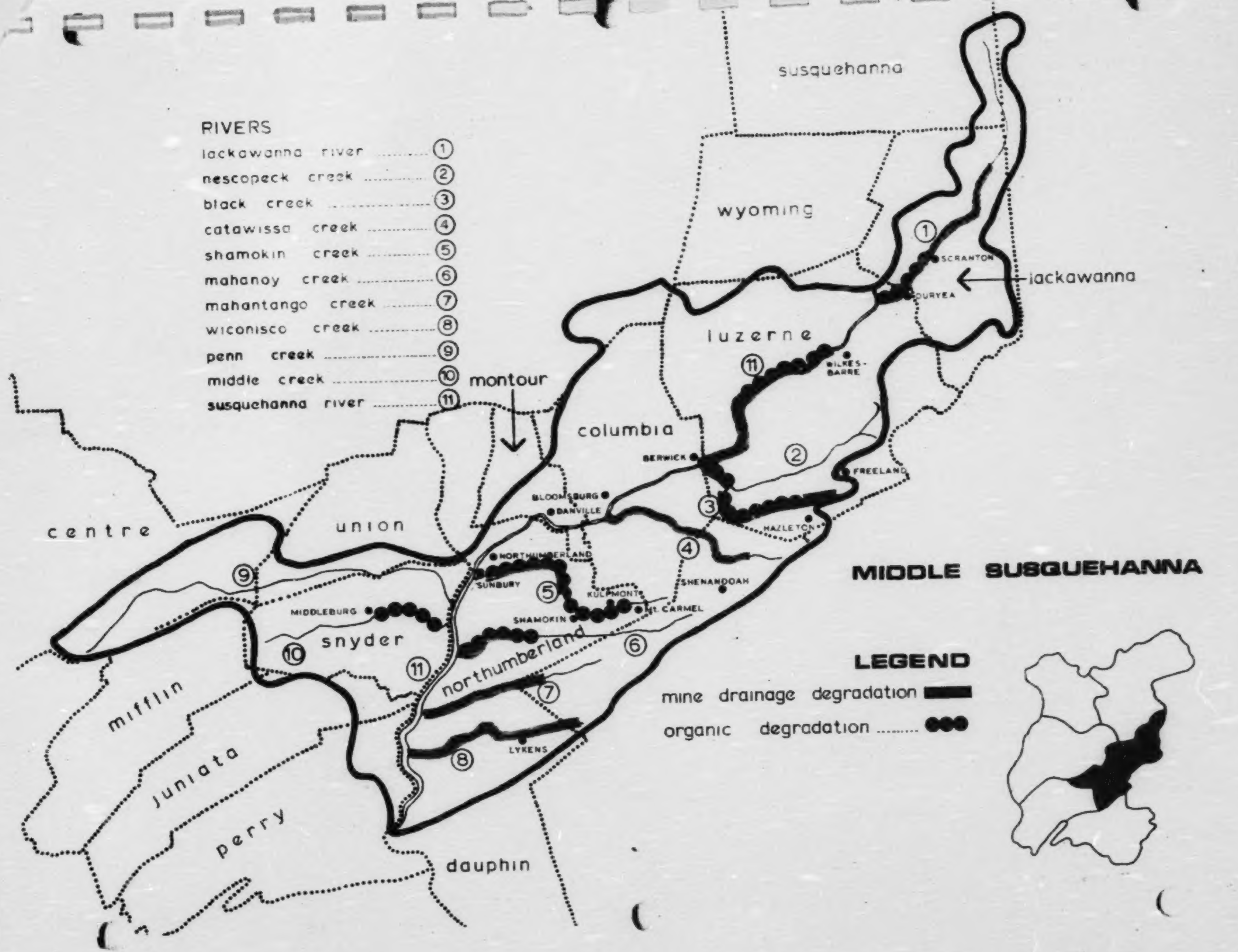

MIDDLE SUSQUEHANNA
RIVERS
lackawanna river ①
nescopeck creek ②
black creek ③
catawissa creek ④
shamokin creek ⑤
mahanoy creek ⑥
mahantango creek ⑦
wiconisco creek ⑧
penn creek ⑨
middle creek ⑩
susquehanna river ⑪
LEGEND
mine drainage degradation
organic degradation
susquehanna
wyoming
lackawanna
luzerne
montour
columbia
centre
union
snyder
northumberland
mifflin
juniata
perry
dauphin
SCRANTON
DURYEA
WILKES-BARRE
FREELAND
BERWICK
HAZLETON
BLOOMSBURG
DANVILLE
NORTHUMBERLAND
SUNBURY
SHENANDOAH
KULPMONT
MT. CARMEL
SHAMOKIN
MIDDLEBURG
LYKENS

General Description

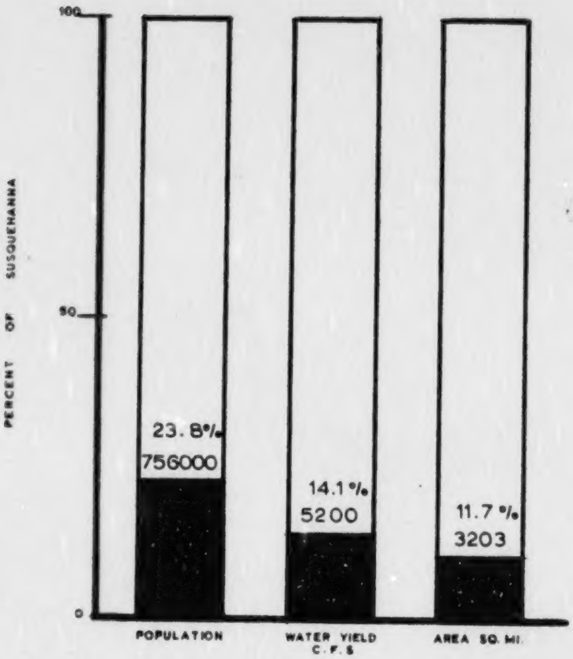
The Middle Susquehanna sub-basin drains an area between the Lackawanna and the Juniata Rivers. It has extremely rugged mountains and narrow valleys with about 52 percetn of the land area covered by forests. The remainder has undergone urban development or has been disturbed by mining. The elevation ranges from 400 to 2600 feet. The streams are swift and turbulent and display good assimilative characteristics. The average annual rainfall is 46 inches.

The sub-basin lies entirely within the Appalachia Region of Pennsylvania and has suffered great reduction of employment in mining. The population is 756,000, about 24 percent of the basin. The economic subregion has been experiencing increasing growth since 1960, with the major portion of growth in the Wilkes-Barre, Scranton, and Hazleton areas. The principal cities, Scranton, Wilkes-Barre, Hazleton, and Shamokin, have long relied on coal mining as the economic base. New industries, however, are being attracted to offset the mining losses; this is especially true in the Hazleton area. The population stands at 750,000, about 24 percent of the total for the entire basin, and is expected to grow to over 1.5 million by 2020.

For purposes of this study, the Middle Susquehanna was divided into 14 water service areas to determine current municipal and industrial uses and to predict future demands on the water resources of the sub-basin. It was divided into 25 sewer service areas to determine current waste handling and sewage treatment practices and to predict future organic waste handling needs. The effects on receiving streams of wastes discharged from the sewage service areas were evaluated.

Only three principal watercourses are generally of good quality: Wapwallopen Creek, Fishing Creek, and Penn Creek. Many streams in this sub-basin are badly degraded by mine drainage and untreated organic wastes. Mine drainage is extremely serious with about 86 square miles, 2.7 percent of the total sub-basin, disturbed by mining operations. Tributaries arising in the mining areas are responsible for about 485,700 pounds of acid per day, 47 percent of the total acid received by all Susquehanna River drainage. Four principal streams are polluted by both mine drainage as well as by organic wastes from towns and industries. These streams are the Lackawanna River, Nescopeck, Shamokin, and Mahanoy Creeks; the Wiconisco Creek is also affected but not so severely as the other four. Two others are severely polluted by mine drainage alone: Catawissa Creek and Mahantango Creek. The Susquehanna itself between Wilkes-Barre and Berwick receives mine drainage both directly and indirectly as well as considerable organic loadings; it is occasionally overcome by this combination during low flows.

Twelve sewer service areas need to install secondary treatment facilities; six of which provide no treatment at present, while six others have primary treatment. There are four areas, Scranton, Hazleton, Shamokin, and Shenandoah, that will eventually need to achieve high level BOD removal so that the Lackawanna River, Black Shamokin, and Shenandoah Creeks can maintain a dissolved oxygen level of 5.0 mg/l. Those efforts, however, should be concomitant with measures to alleviate the mine drainage pollution problems afflicting these same watercourses.



percent of total susquehanna basin

An understanding of surface and ground water resources is basic to effective water quality management programs commensurate with both quality and quantity for the various uses of water. In general, the quality and quantity of the ground waters in the Middle Susquehanna sub-basin are adequate to meet the anticipated demands in the area.

Waste assimilative capacities of the streams of the sub-basin are a function of flow and temperature during the critical summer season from July through October. Major tributaries of the sub-basin, shown in the following table, exhibit wide fluctuations of stream flow and clearly indicate the effects of drought conditions. This must be considered in water quality management programs.

Stream Flow Characteristics at Selected Locations

Stream and Gauge*	Flow Extreme		Mean An. Flow	August Flow Data		
	Max.	Min.		Mean Flow	1-in-20-yr. Low Flow	Min. Daily
Lackawanna River At Archbald	9510	3	196	84.4	32.1	27.4
Lackawanna River at Old Forge	31,000	20	514	262	80	49.5
Susquehanna River at Wilkes-Barre	232,000	528	13,040	3970	1,000	853
Fishing Creek near Bloomsburg	18,000	7.6	460	133	19	15.5
Susquehanna River at Danville	250,000	508	15,050	5,000	1200	1091

Harvey's Lake, with an area of 615 acres, suffers chronic pollution in some locales. The Francis Slocum Dam, a completed man-made impoundment with 165 acres, is a good quality body of water. The body of water resulting from installation of an inflatable dam in the Susquehanna at Sunbury may suffer from excessive coliform and nutrient levels.

Lake or	County	Surface Area Acres	Quality Description
Middle Creek	Snyder	200	Good
Harvey's Lake	Luzerne	615	Chronic localized pollution
Francis Slocum Dam	Luzerne	165	Good
Susquehanna River at Sunbury	Northumberland	---	Studies needed

Economic Base

The Middle Susquehanna economic subregion includes the counties of Columbia, Lackawanna, Luzerne, Montour, and Northumberland. In 1960, the most heavily populated counties were Lackawanna and Luzerne where the Wilkes-Barre--Scranton urban corridor lies. During the 1950-1960 decade, the region experienced a more than 10 percent decrease in population characterized by a heavy outmigration of people in the 20-34 age bracket. Luzerne, Lackawanna, and Northumberland counties were the focal points of the exodus as employment in anthracite mining and in textile manufacturing declined significantly. Increased employment opportunities within the area, however, will reverse this trend so that by 1990 the region's population will be about 20 percent above the 1960 level. Lackawanna and Luzerne will account for most of the absolute growth and Northumberland's population will decline by about 25 percent. By 2020, the population will be twice as large as it was in 1960.

The expansion of total employment within the Middle Susquehanna subregion is projected to be less than that for the Susquehanna Basin as a whole and the nation because of the relatively slow growth in both the manufacturing and the non-manufacturing sectors. However, recovery within the subregion is expected to increase during the 1970's and will be part of the general Pennsylvania recovery process.

Manufacturing accounted for about 39 percent of total employment within the Middle Susquehanna drainage area, compared with about 26 percent nationwide and about 36 percent in the Susquehanna Basin as a whole. Manufacturing employment is projected to grow at a slower rate than is for the nation and the basin, but it will continue to represent a slightly larger percentage of total employment throughout the projection period.

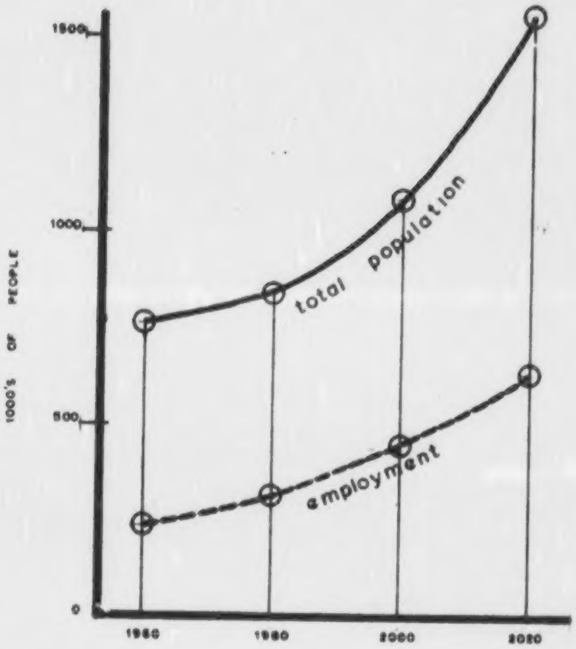
There are six industries in which rapid growth is projected to occur: ordnance, electrical equipment, rubber and plastics, instruments, transportation equipment, and fabricated metals. If this growth is realized, about 20,000 new jobs will be available by 1990.

In 1960, the apparel industry accounted for more than one-third of total manufacturing employment. It will decline moderately through 1990, but in the final analysis will account for about 25 percent of total manufacturing employment. Textiles declined during the 1950's and will continue to decline until in 1990 it will be at 45 percent of its 1960 level of employment.

Nonmanufacturing employment will be about as slow in growing as manufacturing employment. In 1960, agriculture provided about three percent of total employment, but by 2020 it will fall to about 1.5 percent. Employment in tobacco industries will decrease to about 2500 jobs by 1990. Mining represents a much larger portion of total employment than it does in any of the other five sub-basins or in the nation. However, mining is of considerably less importance than it was in 1950 when it exceeded more than 15 percent of total employment in the Middle Susquehanna area. The serious contraction in the anthracite coal industry during the 1950-1960 decade caused employment to plummet drastically; it fell from more than 50,000 to less than 12,000. Lackawanna, Lucerne, and Northumberland Counties, which accounted for more than 90 percent of total anthracite tonnage in 1950, were severely affected.

The services sector will supply the greatest number of new jobs, rising from about 16 percent of total employment in 1960 to 35 percent in 2020. By 2020, construction will represent over nine percent of total employment.

population & employment trends



Employment in government and the retail trades will also experience significant increases.

Employment in the major water using industries accounted for about ten percent of total employment in 1960. It is projected to decline by 1990 primarily because of the expected contraction of textile employment. Although the output of the petroleum industry is forecast to expand rapidly by 1990, employment in this sector is, and will continue to be, comparatively unimportant. The seemingly peculiar trend in pulp and paper output can be explained by a significant decline in employment after 1980 which, in spite of increases in productivity, will cause output to fall below the levels of earlier years.

The following table gives the percent change in total output from 1960 to 1990 for the large water using industries.

Projected Growth in Output for Major Water Using Industries
(in percent)

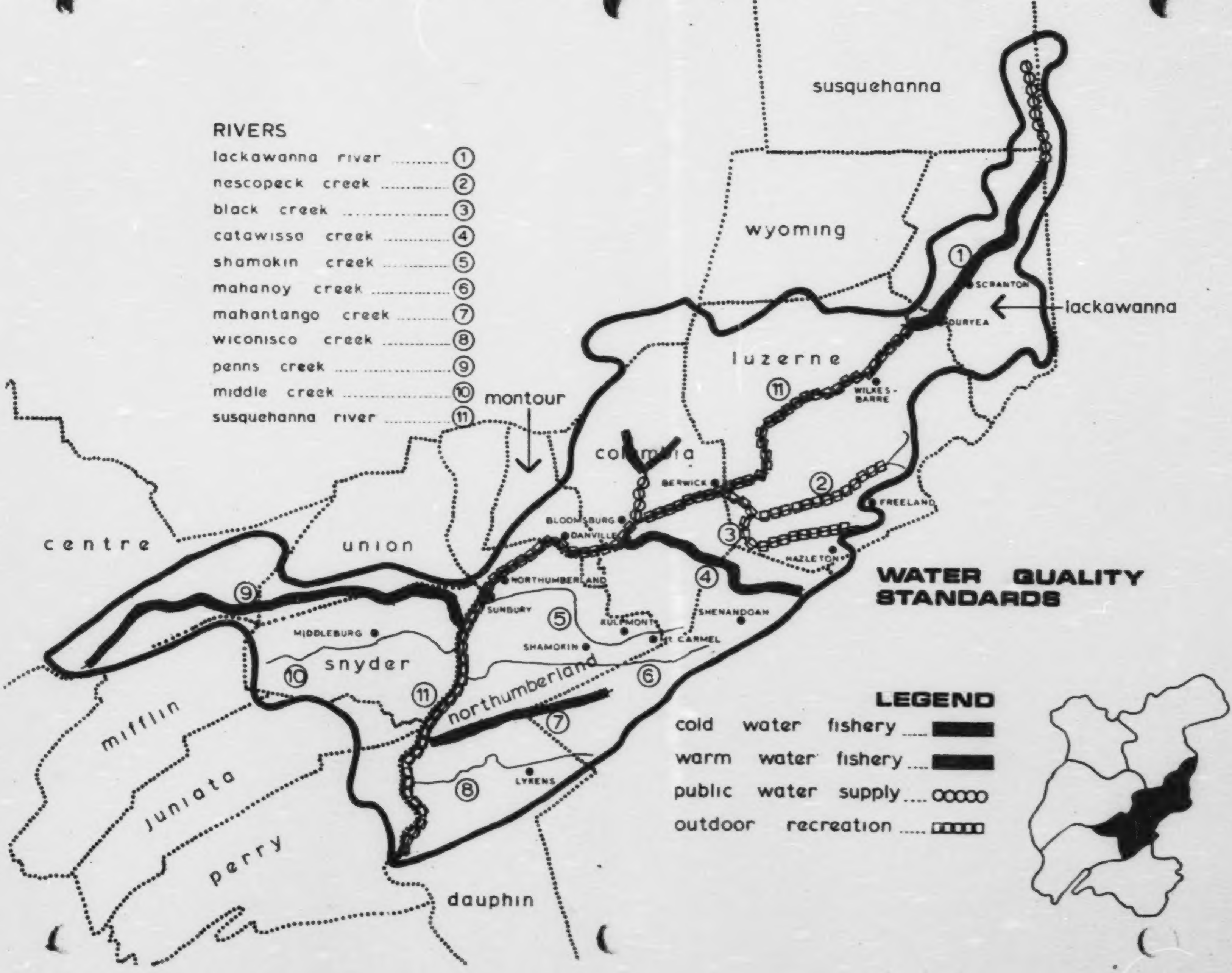
	1960 to 1970	1960 to 1980	1960 to 1990
Food	41	99	169
Textiles	46	72	99
Paper	137	163	22
Chemicals	58	156	334
Petroleum	110	292	624
Primary Metals	48	94	147

Population and industrial growth projections as summarized above were used to project future waste loadings for the Middle Susquehanna sub-basin.

WATER QUALITY MANAGEMENT OBJECTIVES

Water Quality Standards and Present and Future Uses of Water

WATER QUALITY STANDARDS



Water Quality Standards

Standards have been established for the two interstate reaches of the Susquehanna River in this sub-basin. The first reach includes that stretch of the river from the confluence of the Susquehanna with the Lackawanna downstream to the confluence of the Susquehanna with the West Branch. The second reach is from the West Branch to the Juniata River. These reaches are designated in the Pennsylvania water quality standards to be reserved for migratory fish and boating. Judging by the standards already set for other intrastate streams of Pennsylvania, parameters for determining water quality will be dissolved oxygen (5.0 mg/l), color (maximum of 50 units), and temperature (maximum rise of 5 F or maximum temperature of 87 F, except in waters reserved for migratory fish).

Recreation Uses

Recreation demands, at present, are quite heavy, but the people who use the waters of this sub-basin both for fishing and water contact sports are restricted to those waterways not degraded by mine drainage or organic pollution. The unpolluted waters of the Middle Susquehanna are used heavily for both activities, and the people who cannot find adequate opportunity to enjoy these kinds of recreation travel to places outside the area. If more water based recreational opportunity were available, the market population that could exert a demand is 1.1 million, 240,000 more than the actual population of the sub-basin. There are 163 miles of streams and 10,800 acres of lakes in the area. Only 4690 acres are considered acceptable for public recreational uses at the present, and the current use is estimated at 7.3 million recreation user-days and one million user-days of boating activities each year.

The future needs of the sub-basin are estimated below, but recreational demands for water may not be accurately reflected because of access. A new interstate highway from the east will provide an explosive boost to the somewhat lethargic growth of the recreation enterprises in the area.

Projected Recreation Uses

Target Year	Rec. Market Area Pop. (1000's)	Demand Million Days/Yr. Rec.	Demand Million Days/Yr. Boating	Supply Million Days/Yr. Rec.	Supply Million Days/Yr. Boating	Deficit Million Water-Oriented Rec. Days/Yr.
1980	1415	15.43	2.15	5.91	5.32	9.52
2000	1852	25.40	3.74	5.97	5.73	19.43
2020	2500	40.14	5.73	6.85	5.88	33.29

There is an inflatable dam presently under construction near Sunbury, Pennsylvania, which should greatly enhance the recreational potential of the sub-basin.

There are also 98,800 fishermen who use the waters of this region at the estimated rate of 1.8 million user-days per year. They spend about 8.4 million dollars on supplies and transportation in these activities. Most of the demand is exerted on warm water fisheries, but there are 148,000 days spent in trout fishing per year as well. These people have access to 796 miles of warm water streams and 23,460 acres of lakes. Many potential reaches, however, suffer from mine drainage pollution which renders them useless for these activities.

Year	Fishermen (1000's)	Fisherman Days/Year (Millions)	Annual Expenditures (Millions)
1980	169.6	3.25	14.5
2000	227.4	4.41	19.6
2020	303.9	5.47	26.7

Municipal and Industrial Uses

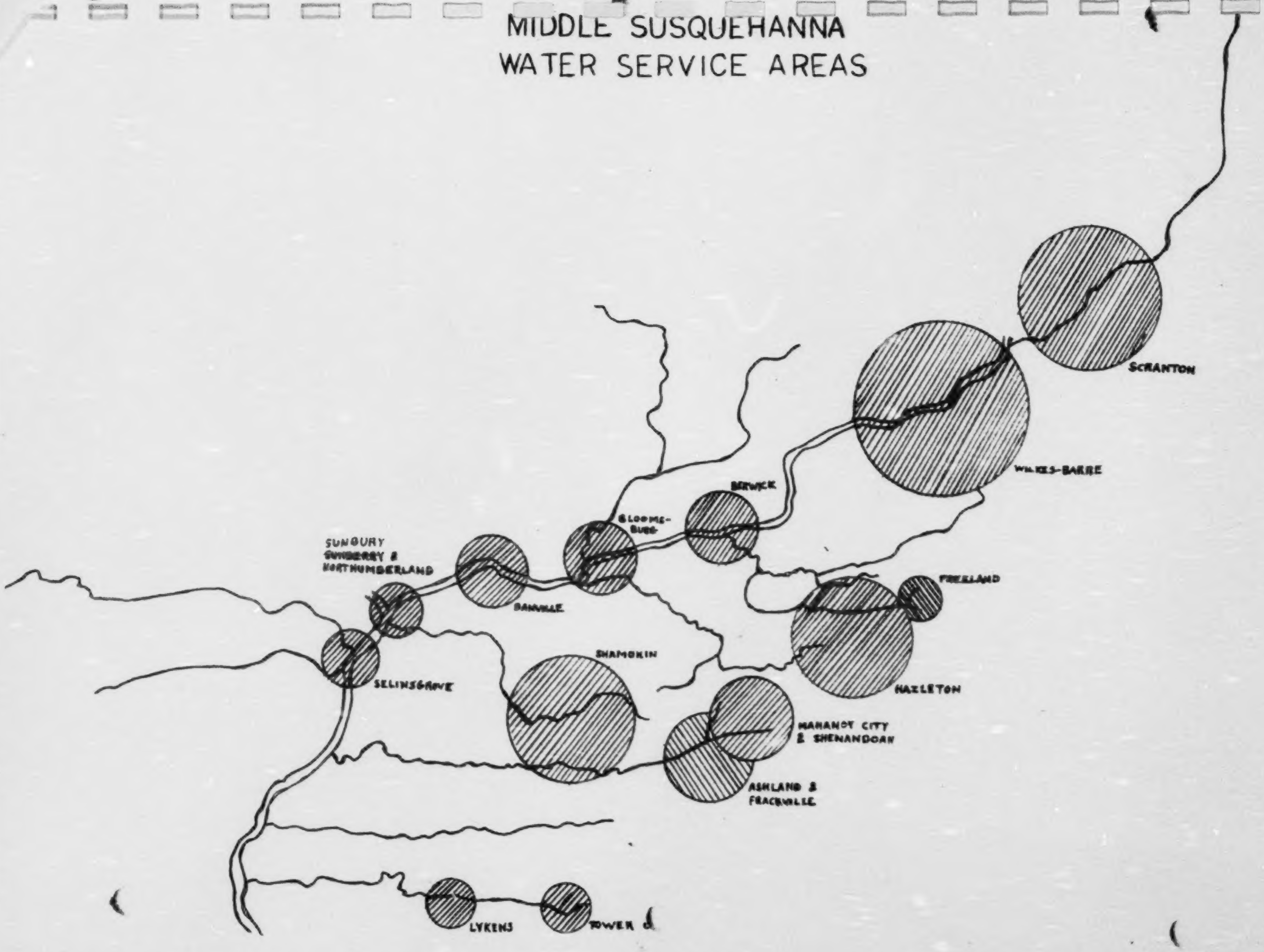
Municipal and industrial water needs were evaluated on the basis of 14 principal water service areas, serving 729,000 people with about 188 million gallons per day. Most of this water comes from clean tributary streams that are already near their dependable yield for water supply. There are transfers to this basin from the Delaware for Hazleton and Scranton public water supplies. Hazleton transfers about six million gallons per day and Scranton transfers one million gallons per day into the Susquehanna Basin. If Scranton and Wilkes-Barre grow as projected, much of their future supplies will probably come directly from the Susquehanna River itself, rather than the small tributaries now in use. The city of Danville already taps the Susquehanna directly. By 2020, population will at least double and water demands for municipal and industrial uses will more than double.

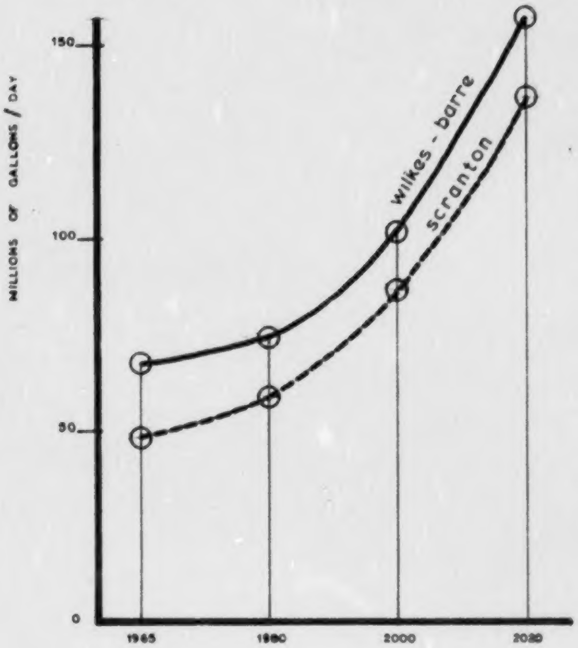
Projected Direct Withdrawals from Susquehanna River

Water Service Area	Year	Population Served (1000's)	Est. Total Mun. Water Required mgd
Scranton	Present	207.4	49.6
	1980	257.5	59.2
	2000	326.3	88.8
	2020	466.0	137.0
Wilkes-Barre	Present	263.0	69.2
	1980	327.0	75.4
	2000	413.0	104.4
	2020	586.0	161.0
Danville	Present	11.5	28.2*
	1980	14.6	20.1
	2000	18.2	21.6
	2020	24.0	27.2

* Anticipated water conservation

MIDDLE SUSQUEHANNA
WATER SERVICE AREAS





future needs at scranton & wilkes-barre

Total Water Uses in the Sub-basin

Year	Pop. Served (1000's)	Municipal Water (mgd)	Industrial Water (mgd)	Total Water (mgd)
Present	729.1	112.5	75.9	188.4
1980	868.7	144.5	64.1	208.6
2000	1078.6	207.0	85.9	292.9
2020	1514.4	327.6	114.6	442.2

Irrigation Uses

Irrigation demands are not significant. Most of the requirements occur along the Susquehanna River between Wilkes-Barre and Selinsgrove, Pennsylvania. The Department of Agriculture has made projections for irrigation demands to be supplied by surface water sources during low flows through the year 2020. Consumption will be greater than twice as much by 2020, and the accompanying rise in instantaneous demand will parallel consumption.

Irrigation Demand

Year	Est. Acres Irrigated	Water Consumption (Acre-Ft.)	Estimated Maximum Instantaneous Demand (cfs)
Present	1860	2600	22
1980	2040	2850	25
2000	3120	4370	39
2020	4470	6250	57

Cooling Water Uses

Electric power generation has an installed capacity of 630 MW supplied by three plants. Pennsylvania Power and Light has steam-electric plants located at Exeter, Hunlock Creek, and at Shamokin Dam. The Hunlock Creek Plant at Wilkes-Barre is located about 15 miles downstream from the Stanton Plant at Exeter. Both of the plants use the Susquehanna River as a source of cooling water and employ the once-through cooling method; they all discharge their thermal wastes to the Susquehanna River.

Electrical Power Generation

Plant	Installed Capacity 1000's KW	mgd	cfs	Est. Aug. Stream Flow 1-in-20-yr. cfs
Hunlock Wilkes-Barre, Pa.	93.0	97.2	151	1100
Sunbury Plant Shamokin Dam, Pa.	397.8	324.0	502	2400
Stanton Exeter Twp., Pa.	140.5	43.0	67	1100

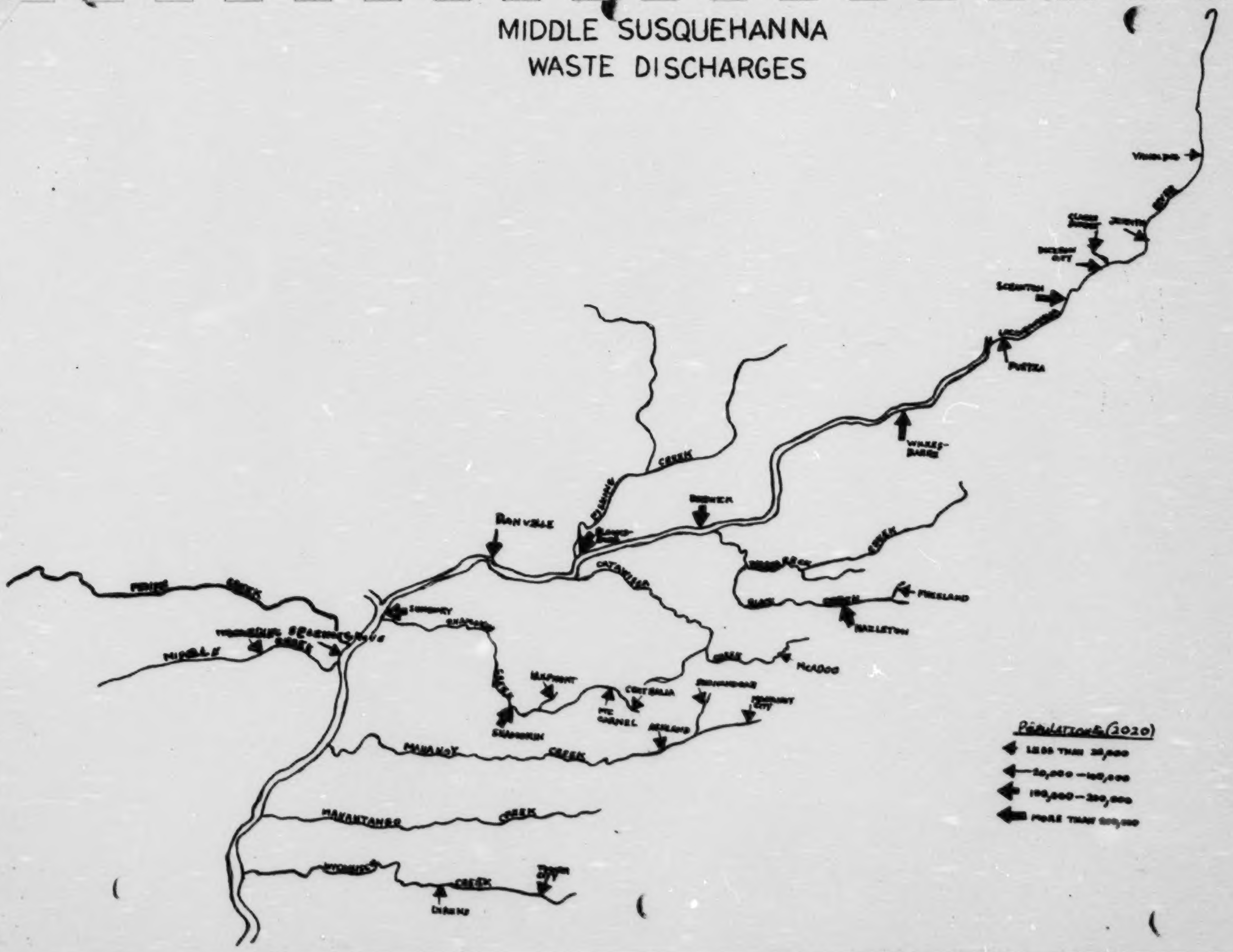
The Pennsylvania Power and Light Company is presently conducting a study on the feasibility of building an atomic plant near Berwick. It is still in very early planning stages, and there is not yet enough information to make statements on its probable effects upon the river.

SOURCES, PROBLEMS,

AND

POLLUTION ABATEMENT

MIDDLE SUSQUEHANNA
WASTE DISCHARGES



Sources of pollution were enumerated and evaluated, resulting in specific pollution abatement actions necessary. The table below summarizes the current conditions in the sewer service areas and identifies immediate pollution control needs.

SEWER SERVICE AREAS AND IMMEDIATE NEEDS SUMMARY

Sewer Service Area	Present Capacity (mgd)	Present Treatment Level	Immediate Treatment Level Needs (Jan. 1969)	Max. Allowable BOD Discharge (lb)
Vandling	---	None	Secondary	220
Jermyn	---	None	Secondary	2,000
Dickson City	---	None	Secondary	2,000
Scranton (incl. Dunmore)	20	Secondary	Advanced	5,100
Duryea	---	None	Secondary	2,000
Freeland	---	None	Secondary	260
McAdoo	---	None	Secondary	250
Centralia	---	None	Secondary	30
Mt. Carmel	---	None	Secondary	250
Kulpmont	---	None	Secondary	50
Shamokin	---	None	Secondary	2,000
Mahanoy City	---	None	Secondary	250
Ashland	---	None	Secondary	400
Shenandoah	---	None	Secondary	100
Tower City	---	None	Secondary	600
Middleburg	0.2	Primary	Secondary	1,700
Wilkes-Barre	40	Primary	Secondary	15,000
Berwick (incl. Wise Potato Chips)	3.7	Primary	Secondary	15,000
Bloomsburg	4.3	Primary	Secondary	15,000
Danville (incl. Merck and Company)	3.2	Intermediate	Secondary	20,000
Sunbury	3.0	Primary	Secondary	1,200
Clarks Summit	0.4	Secondary	---	
Hazleton	5.8	Secondary	---	
Lykens	0.3	Secondary	---	
Selinsgrove	0.9	Secondary	---	

The following sections present an evaluation of sources, problems, as well as the necessary pollution abatement actions required. These actions are aimed towards providing water quality commensutate with the anticipated growth and development of the Middle Susquehanna sub-basin.

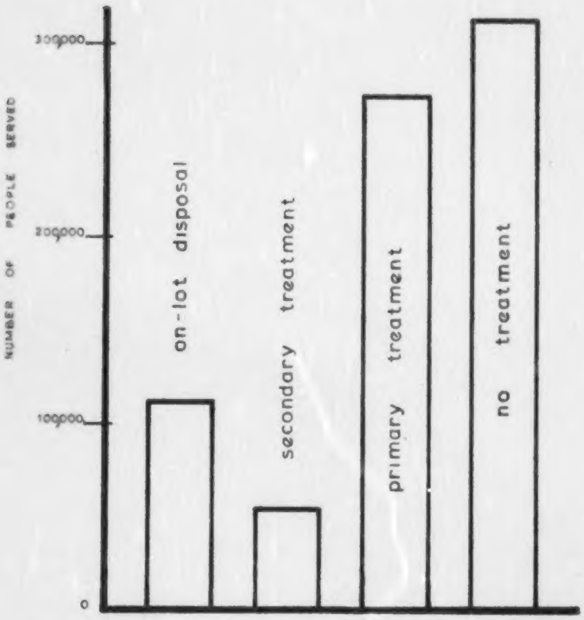
SOURCES AND PROBLEMS

Municipal and Industrial Wastes

In this sub-basin, about 643,000 people are serviced by sanitary sewers. There are about 272,300 people whose waste receives primary treatment, while 55,000 people have secondary treatment facilities. Approximately 115,500 people utilize on-site disposal systems, usually septic tanks. Some 316,500 people discharge directly into receiving streams without any treatment. This is most common in the Lackawanna and Wyoming Valleys at the cities of Scranton and Wilkes-Barre.

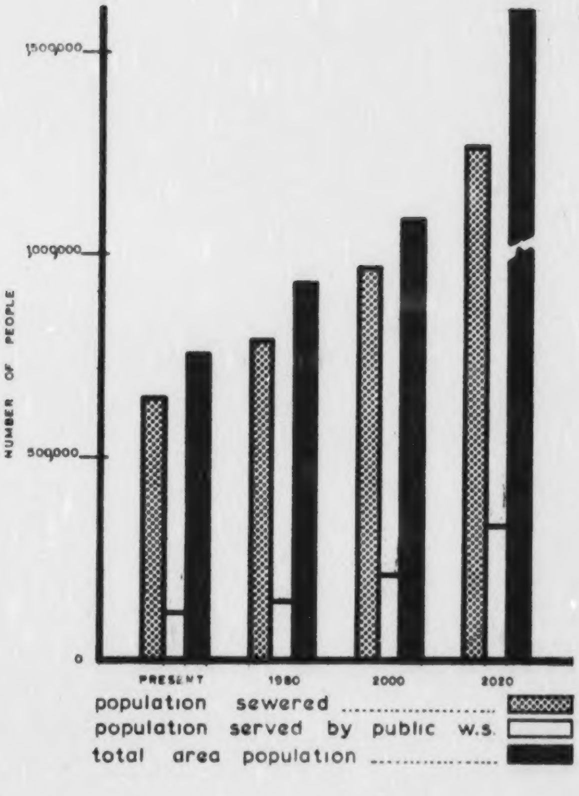
The total loading before treatment and population equivalents is 956,700, including all industrial and municipal wastes. Of this amount, 502,000 population equivalents are discharged after treatment, equal to raw wastes from a population of 502,000.

Organic waste problems are complicated by mine drainage pollution, and those streams that suffer the most from organic pollution are also the ones most severely degraded by mine acids. Scranton discharges to the Lackawanna; Hazleton to Black Creek: Shamokin to Shamokin Creek; and Shenandoah to Shenandoah Creek, a tributary of Mahanoy Creek. The land along these waterways is defaced by culm piles and scared with strip mines.

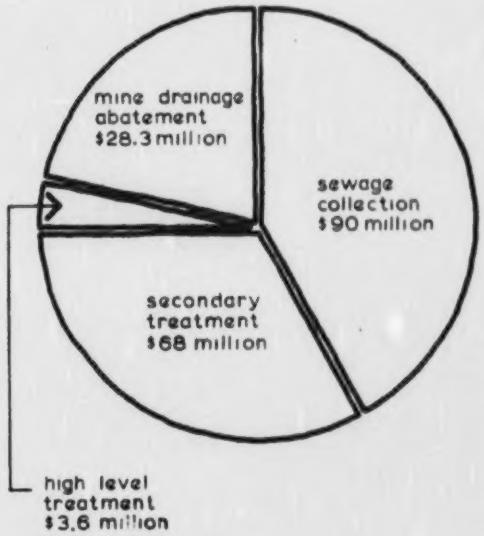


breakdown of treatment methods (1968)

collection & treatment



costs of recommended abatement measures (1965-1980)



ABATEMENT

Municipal and Industrial Wastes

To meet and maintain the dissolved oxygen requirements specified in the stream standards for this sub-basin, all 25 sewer service areas should have a minimum of secondary treatment facilities operating in the nea rfuture. Four sewer service areas need to upgrade treatment to high level BOD removal. Scranton needs high level BOD removal because of the large volume of wastes in comparison to the size of the receiving stream. High level BOD removal will be a necessity at Hazleton, Shamokin, and Shenandoah as mine drainage in the watersheds is abated. These facilities should be constructed at the same time that mine drainage is abated.

Pollution problems in this sub-basin will be partially remedied by late 1969 when the Wyoming Valley Sewer Authority places its new primary treatment plant into operation. It will serve about 220,000 people and relieve the Susquehanna of 250,000 population equivalents below Wilkes-Barre. The city of Scranton also will be completing a secondary treatment plant by 1970. In addition to the Scranton plang in the Lackawanna River Valley, four more secondary plants are scheduled for completion by 1972; these are expected to add materially to BOD reductions to the Lackawanna River.

Along with these expanded treatment facilities, there will have to be collateral expansion of the collection facilities.

Cost of Collection Facilities

Time Period	New Population Served (1000's)	Total Cost Estimate (Millions)
By 1980	142.0	90
1980-2000	186.0	110
2000-2020	404.0	224

To achieve and maintain the secondary treatment levels hoped for beyond 1980, costs as indicated in the following table are anticipated:

Time Period	Pop. (1000's)	Pop. Eq. (1000's)	Estimated Capital Needs (Millions)	Estimated Av. An. Exp. O&M (1000's)	Estimated Av. An. Exp. Total* (1000's)
By 1980	791	1358	68	1318	6390
1980-2000	977	1776	72	1793	7075
2000-2020	1381	2434	36	2513	9120

* Includes amortization of capital at 4 percent, 20 years.

The Pennsylvania Department of Forests and Waters requires releases from reservoirs in the Lackawanna Watershed of 0.1 cfs/sq mi. This is frequently not achieved in the Lackawanna River with the result that Scranton wastes exceed the river's assimilative capacity. Although even more flow augmentation would probably be needed, the legal provision to release the required 0.1 cfs per sq. mile from water supply reservoirs should be enforced. Additional flow augmentation could be provided by reservoir site #37-20 of the Susquehanna River Basin study, and this possibility should be thoroughly investigated.

Cost estimates for high level organic waste removal at Scranton and Hazleton are as follows:

Costs for High Level BOD Removal

Time Period	Pop. Eq. (1000's)	Estimated Capital Needs ($ Millions)	Estimated Av. An. Exp. O & M (1000's)	Estimated Av. An. Exp. Total* (1000's)
By 1980	419	3.6	56.0	317.7
1980-2000	523	4.6	80.4	417.4
2000-2020	688	6.2	110.3	569.2

* Includes amortization of capital at 4 percent over 20-year period.

If the recommendations are followed, total costs to be expected for all waste treatment in this sub-basin are as summarized below. Costs do not include the cost of collection facilities.

Total Costs of Recommended Treatment Facilities *

Time Period	1000's Population Equivalent Received	1000's Population Equivalent Discharged	Capital Needs $ Millions
1965	959	735	
1965-1980	1358	178	71.6
1980-2000	1776	230	77
2000-2020	2434	317	42

* Costs do not include nutrient removal.

SOURCES AND PROBLEMS

Mine Drainage

This sub-basin contains nearly all of the anthracite mining activity of the basin and most of the sources of mine drainage arising from the anthracite workings. Many of the workings are now abandoned. Seven principal watersheds are sources of the mine drainage: Lackawanna, Nescopeck, Catawissa, Shamokin, Mahanoy, Mahantango, and the Wiconisco watersheds. The mine drainage loads from the Lackawanna, Nescopeck, Shamokin, and Mahanoy Creeks are complicated by gross organic pollution. In addition, there is mine drainage on the east side of the Susquehanna River between Wilkes-Barre and Nescopeck that contribute significant amounts of acid and iron. Other than the four creeks mentioned above, loads come from eight major sources in the Wyoming Valley that contribute about 572,000 pounds of acid per day to the water of this sub-basin. All of the receiving streams are seriously degraded and even the Susquehanna itself is badly affected in the reach from Wilkes-Barre to Berwick. The total flow of acid is 316.7 mgd, while the acid load per day at the sources totals 572,000 pounds. Iron from these mine drainage sources amounts to a total of 195,600 pounds per day.

Principal Receiving Stream	Acid Flow mgd	Acid Flow cfs	Acid Load at Sources lb/day	Iron lb/day
Lackawanna River	75.3	116.8	143,000	62,900
Wyoming Valley Tribs.	58.8	91.0	142,000	62,300
Nescopeck Creek	43.0	66.6	78,800	5,100
Catawissa Creek	29.2	45.2	27,500	700
Shamokin Creek	24.6	38.2	32,800	25,500
Mahanoy Creek	63.5	98.4	44,000	33,400
Mahantango Creek	9.2	14.3	6,000	2,200
Wiconisco Creek	13.1	20.3	2,200	3,500
	316.7	490.8	476,300	195,600

ABATEMENT

Mine Drainage

Mine drainage abatement in the Middle Susquehanna sub-basin can be undertaken through an optimum mix of preventive measures and treatment methods. Cost estimates for mine drainage abatement in this report are based on design data supplied through contracted study with Gannett Fleming Corddry and Carpenter, Inc. This consultant firm studied five representative watersheds throughout the basin for the express purpose of providing the FWPCA with general cost estimates for mine drainage abatement. Costs from these studies were related to acid quantity in mgd/day and in pounds per day and iron in pounds per day. The type of mining and the nature of the surface disturbance were also taken into consideration.

Generally, abatement measures begin with physical preventive measures such as reconstructing stream channels that have been disturbed by mining activity and constructing barriers so that water is generally kept from entering the mines. These preventive measures are designed to withhold the water so that it is not polluted. In the event of extreme flood, it is next to impossible to keep the water out of contact with the polluting materials and in these cases a treatment plant is provided to curtail the pollution. Treatment generally includes such things as chemical neutralization, oxidation, flocculation, and sludge conditioning. Treatment nearly always accompanies preventive measures. Lime neutralization, the cheapest and therefore the one that will probably be turned to most, seldom removes more than 25 percent of the remaining acid load.

Watershed	Average Acid Flow (lb/day)	Average Acid Flow After Preventative Measures (lb/day)	Estimated Treatment Costs (Millions) First	Estimated Treatment Costs (Millions) Total Annual	Estimated Treatment Costs (Millions) Annual O & M
Lackawanna R.	143,000	107,300	4.52	1.40	1.14
Wyoming Valley	142,000	106,500	4.59	1.46	1.03
Nescopeck Creek	78,800	59,000	1.51	0.71	0.62
Catawissa Creek	27,500	20,500	1.19	0.41	0.34
Shamokin Creek	32,800	24,600	2.33	0.62	0.49
Mahanoy Creek	44,000	33,000	3.26	0.96	0.77
Mahantango Creek	6,000	4,500	0.41	0.13	0.11
Wiconisco Creek	2,200	1,600	0.72	0.21	0.17

Treatment measures cannot be relied upon alone to solve the problem. They are designed to be used only as a supplement to physical preventive measures.

Watershed	Total First Cost (Millions)	Total Avg. Annual Cost (1000's)	Operation & Maintenance (1000's)
Lackawanna River	13.99	2273	1409
Wyoming Valley Tribs	11.95	2123	1215
Nescopeck Creek	7.79	1280	780
Catawissa Creek	6.16	875	509
Shamokin Creek	8.67	1230	710
Mahanoy Creek	17.12	2310	1288
Mahantango Creek	2.33	310	178
Wiconisco Creek	3.18	450	262

MISCELLANEOUS WATER
QUALITY PROBLEMS

Nutrients

Algal blooms are common in the Lackawanna River from Carbondale to Old Forge. In the Lackawanna, algal blooms suddenly disappear at Old Forge because at this point the river becomes so acid that the algae are inhibited and, therefore, cannot take advantage of the nutrients present. It is suspected that this is the same reason there are no algal blooms in the Nescopeck, Shamokin, and Mahanoy Creeks; the acid conditions in these streams combine with their natural swiftness and prevent the algae from growing. Agricultural runoff is not a significant factor in the overall pollution problems of this sub-basin.

Combined Sewers

Combined sewer systems are extensively used in this sub-basin. There are 15 communities involved and they utilize altogether seven streams to receive the combined wastes. Thirteen of these cities provide no treatment; Wilkes-Barre provides primary treatment and Scranton will have secondary treatment by 1970.

Communities With Combined Sewer Systems

Dickson City
Clarks Summit
Scranton
Freeland
Hazleton
McAdoo
Wilkes-Barre
Berwick
Danville
Mt. Carmel
Shamokin
Sunbury
Ashland & Frackville
Mahanoy City
Shenandoah

Thermal Pollution

Thermal problems are the result of the once-through cooling method used by the electric power plants at the Hunlock plant in Wilkes-Barre, the Stanton Plant at Exeter, and the Sunbury plant at Shamokin Dam, all owned by the Pennsylvania Power and Light Company. The plants constitute pollution loadings at three points along the Susquehanna River. In all three cases, however, water use for condenser cooling consists of less than one-fifth of river flow during drought conditions.

The Pennsylvania Power and Light Company anticipates construction of an atomic power facility near Berwick within the next ten years.

Individual Waste Disposal Systems

There are presently 113,500 people using on-lot waste disposal. By 1980, this figure is expected to increase to 133,800, and by 2020, to 158,800. Failure of individual disposal systems cause periodic local water quality problems in this sub-basin.

ABATEMENT

Nutrients

Although there is evidence that nutrients are causing water quality problems in this sub-basin, no specific abatement actions to remove nutrients from waste waters is recommended at this time. In the future, nitrate and phosphate removal will probably be required at Scranton, Pennsylvania. Study efforts should continue to determine the levels of phosphorus and nitrogen in the streams and to identify stream reaches where these nutrients may be the cause of water quality degradation.

Combined Sewers

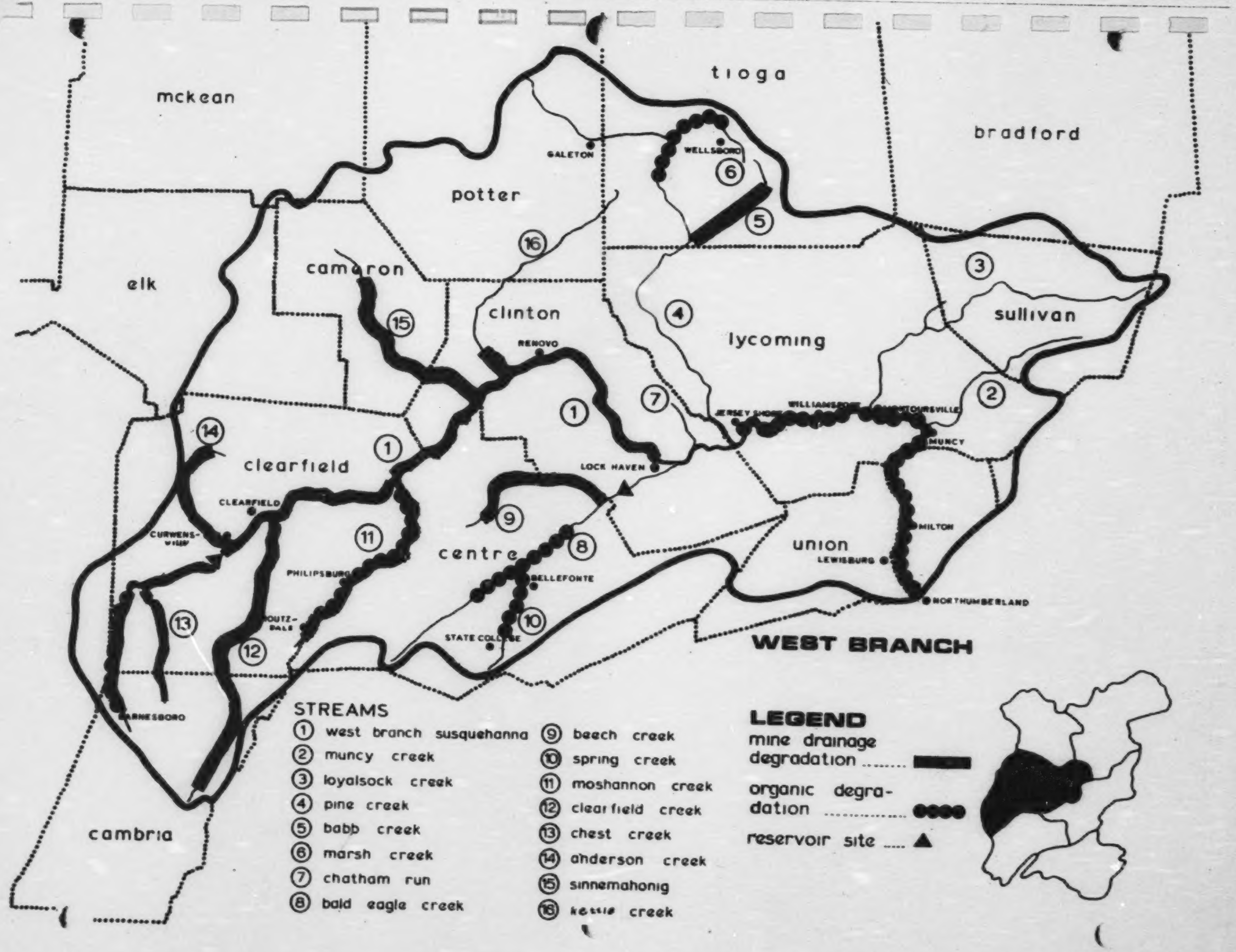
Numerous methods of eliminating the adverse effects caused by combined sewer discharges are currently under intensive study, but at the present no economically feasible method is available for abating pollution from this source. Until a practical solution is found, it is assumed that existing combined sewers will continue to be used. The Pennsylvania Sanitary Water Board has required that a separate sewer system in all future urban developments in the Scranton-Wilkes-Barre area be installed. It is recommended that no new combined sewers be built.

Thermal Pollution

It is anticipated that the Stanton and Hunlock Creek plants will be phased out by 1990. Since the Sunbury plant uses less than one-fifth of the river flow for condenser cooling, there appears to be no necessity for installation of forced cooling facilities. However, any significant expansion of the Sunbury plant should provide for forced cooling. The proposed atomic plant at Berwick should provide an adequate degree of forced cooling.

Individual Waste Disposal Systems

It may not be feasible for all rural populations to connect with regional collection facilities. Pennsylvania administers laws regarding septic tank usage where tank capacity and drain field construction vary with soil type, lot size, and living-quarters capacity. These kinds of facilities can be very efficient when properly designed and maintained, but wherever possible, people are encouraged to connect into a regional collection system.


WEST BRANCH
mckean
tioga
bradford
potter
elk
cameron
clinton
lycoming
sullivan
clearfield
centre
union
cambria
GALETON
WELLSBORO
RENOVO
LOCK HAVEN
JERSEY SHORE
WILLIAMSPORT
MONTOURSVILLE
MUNCY
MILTON
LEWISBURG
NORTHUMBERLAND
CLEARFIELD
CURWENSVILLE
PHILIPSBURG
HOUTZDALE
BELLEFONTE
STATE COLLEGE
BARNESBORO
STREAMS
① west branch susquehanna
② muncy creek
③ loyalsock creek
④ pine creek
⑤ babb creek
⑥ marsh creek
⑦ chatham run
⑧ bald eagle creek
⑨ beech creek
⑩ spring creek
⑪ moshannon creek
⑫ clearfield creek
⑬ chest creek
⑭ anderson creek
⑮ sinnemahonig
⑯ kettle creek
LEGEND
mine drainage degradation ....
organic degradation .... ●●●●
reservoir site ..... ▲

General Description

The West Branch of the Susquehanna River is characterized by rugged mountains and narrow valleys with about 78 percent of the total land area covered by forests. The upper watershed is almost solid forest, although some of the limestone and shale valleys in the State College-Lock Haven-Williamsport areas are intensively farmed.

This sub-basin is projected to experience a fairly rapid rate of population growth, increasing by about 84 percent between 1960 and 1990 and almost tripling over the interval from 1960 to 2020 to nearly one million people. Presently, there are about 350,000 people, eleven percent of the basin's total, living in this sub-basin. This projected rate of growth exceeds that for the Susquehanna Basin and for the United States as a whole. Much of the growth will be concentrated around State College and Williamsport and Milton.

For purposes of this study, the West Branch was divided into 19 water service areas to determine current municipal and industrial uses and to predict demands to be made on the streams of the sub-basin in the future. It was divided into 24 sewer service areas to determine and predict organic waste handling needs and the effects of concentrated waste discharges on receiving streams.

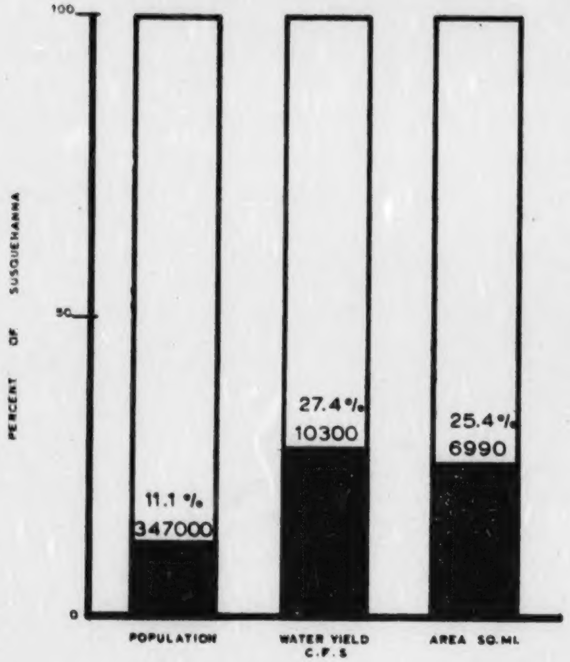
Within the next few years, three sewer service areas along acid streams will install waste handling facilities to attain primary treatment; five areas on good streams that presently have no treatment facilities should install secondary treatment plants and ten areas should upgrade from primary to secondary. Two sewage service areas, State College and University Park, need to maintain 90 to 95 percent BOD removal as well as nutrient removal. Two other areas, Bellefonte and Wellsboro, need to achieve 90 to 95 percent BOD removal.

Mine drainage is also a serious water pollution problem in this sub-basin. Surface mining has disturbed 155 square miles and tributaries arising in the coal fields contribute about 484,000 pounds of acid per day to the waterways of the sub-basin, which is 47 percent of the total acid received from all of the Susquehanna drainage basin.

Large volumes of sewage effluent entering Spring Creek from the State College area pose the most serious organic pollution problem in this sub-basin. Spring Creek, once an outstanding trout stream, has become choked with aquatic weeds and algae as a result of excessive nutrient loadings and silt from highway and other construction activities. In addition to the excessive nutrient enrichment of Spring Creek by the State College area, organic wastes from Lock Haven, Williamsport, and Lewisburg are causing algae and aquatic weed problems in the West Branch below Lock Haven. All three cities provide only primary treatment.

A few of the limestone valleys in the State College-Lock Haven-Lewisburg area are intensively cultivated. In general, however, pollution from agricultural runoff does not seem to be significant. Sedimentation and nutrient enrichment directly attributable to agricultural activity has not been evident.

An understanding of the surface and ground water resources is basic to effective water quality management programs commensurate with both quantity and quality requirements for water uses. In general, the quantity and quality of the ground waters in the West Branch sub-basin are adequate to meet the anticipated demands in certain portions of the area.



percent of total susquehanna basin

Waste assimilative capacities are a function of flow and temperature during the critical summer season from July through October. Major tributaries of the sub-basin, shown in the following table, exhibit wide fluctuations of stream flow and clearly indicate the effects of drought conditions on dependable stream flow which must be considered in water quality management programs. Waste assimilation failure criteria used in determining high level waste treatment needs were based on the once-in-20-years low stream flows. Water supply availability criteria were based on once-in-25-year low stream flows.

Stream Flow Characteristics at Selected Locations

	Instantaneous Flow Extreme		Mean Annual	August Flow Data		
Stream and Gauge*	Max.	Min.	Flow	Mean Flow	1-in-20-yr. Low Flow	Min. Daily
Moshannon Creek at Osceola Mills, Pa.	2,930	6.9	108	38.6	13.5	13
Driftwood Branch at Sterling Run, Pa.	47,800	0.4	444	102	13.1	9
Spring Creek near Axemann, Pa.	1,670	9.6	83.7	53	34.5	28.8
N. Bald Eagle at Beech Creek Sta.	25,600	29	775	279	154	143
West Branch at Williamsport, Pa.	264,000	162	8,714	2,609	700	615

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* Data collected by U.S. Geological Survey

(All measurements are in cfs).

There are a number of man-made lakes in this sub-basin, most of which impound good quality water. The principal ones are listed below.

Lake or Park	County	Surface Area Acres	Quality Description
Prince Gallitzen	Cambria	1740	Good
Curwensville	Clearfield	540	Fair (low alkalinity)
Blanchard (Foster Sayre)	Centre	1730	Good
Black Moshannon	Centre	250	Good
Kettle Creek	Clinton	160	Good
Little Pine	Lycoming	90	Good
Hunters Lake	Sullivan	127	Good
Hills Creek	Tioga	137	Good

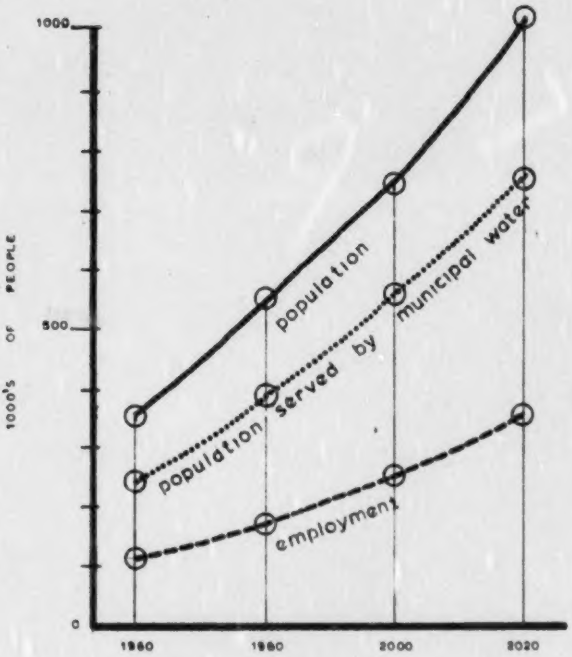
Economic Base

The West Branch subregion includes Cameron, Center, Clearfield, Clinton, Lycoming, and Union counties. These Pennsylvania counties contain about 10 percent of the population, but they are expected to experience a rapid rate of population growth, increasing by about 84 percent between 1960 and 1990 and nearly tripling over the interval from 1960 to 2020. This rate of growth exceeds that for the Susquehanna Basin as a whole and for the nation. Much of the growth will be centered around State College in Center County, Williamsport in Lycoming County; Union County will be affected by growth spilling over from Milton in Northumberland County.

Manufacturing employment constitutes a larger proportion of total civilian employment than it does across the nation, but a smaller proportion than within the Susquehanna Basin. But manufacturing employment is expected to grow very slowly rising by less than 14 percent between 1960 and 2020. Therefore, in the future it will represent a smaller percentage of total civilian employment than it will nationally and basin-wide.

Although some manufacturing industries are projected to experience rapid growth, they will only contribute about 10,000 new jobs to the economy of the area. These rapid growth industries are rubber and plastics, transportation equipment, and printing and publishing. Industrial activity in this subregion has not participated in the expansion experienced in the electronics and related industries elsewhere. Therefore, any increases in employment will take place in other industries with concurrent reductions in electronic oriented industries. Textile employment will fall at twice the rate as that for the entire basin.

population & employment trends



This subregion's per capita income will only be about 90 percent of that for the basin and nation by 2020. It will rise from 1,750 dollars in 1960 to 9,600 in 2020 on the basis of 1960 dollars.

Employment in the major water using industries, which was about nine percent of total employment in 1960, is projected to contract by 1990, primarily because of the decline of the textile industry. Although petroleum output is expected to experience the greatest rate of growth, the level of employment will continue to be low.

The following table gives the percent change in total output from 1960 to 1990 for the large water using industries.

Projected Growth in Output for Major Water Using Industries
(in percent)

	1960 to 1970	1960 to 1980	1960 to 1990
Food	73	174	321
Textiles	34	- 52	- 33
Paper	52	212	197
Chemicals	65	182	384
Petroleum	263	618	1254
Primary Metals	32	77	142

Population and industrial growth projections as summarized above were used to project future waste loadings for the West Branch sub-basin.

Nonmanufacturing employment is projected to account for almost 90 percent of employment in this sub-basin by 2020; its importance to this area will exceed that to the Susquehanna basin as well as the nation. The greatest growth is expected to occur in construction, wholesale trade, finance, government, and services; however, all but the service sector will continue to constitute small shares of the total employment. Agricultural employment is quite small within the West Branch and is projected to fall from its level of 5.5 thousand to less than five thousand in 1980, then to increase to about six thousand employees, or about two percent, in 2020. This is comparable to trends in agricultural employment throughout the Susquehanna Basin.

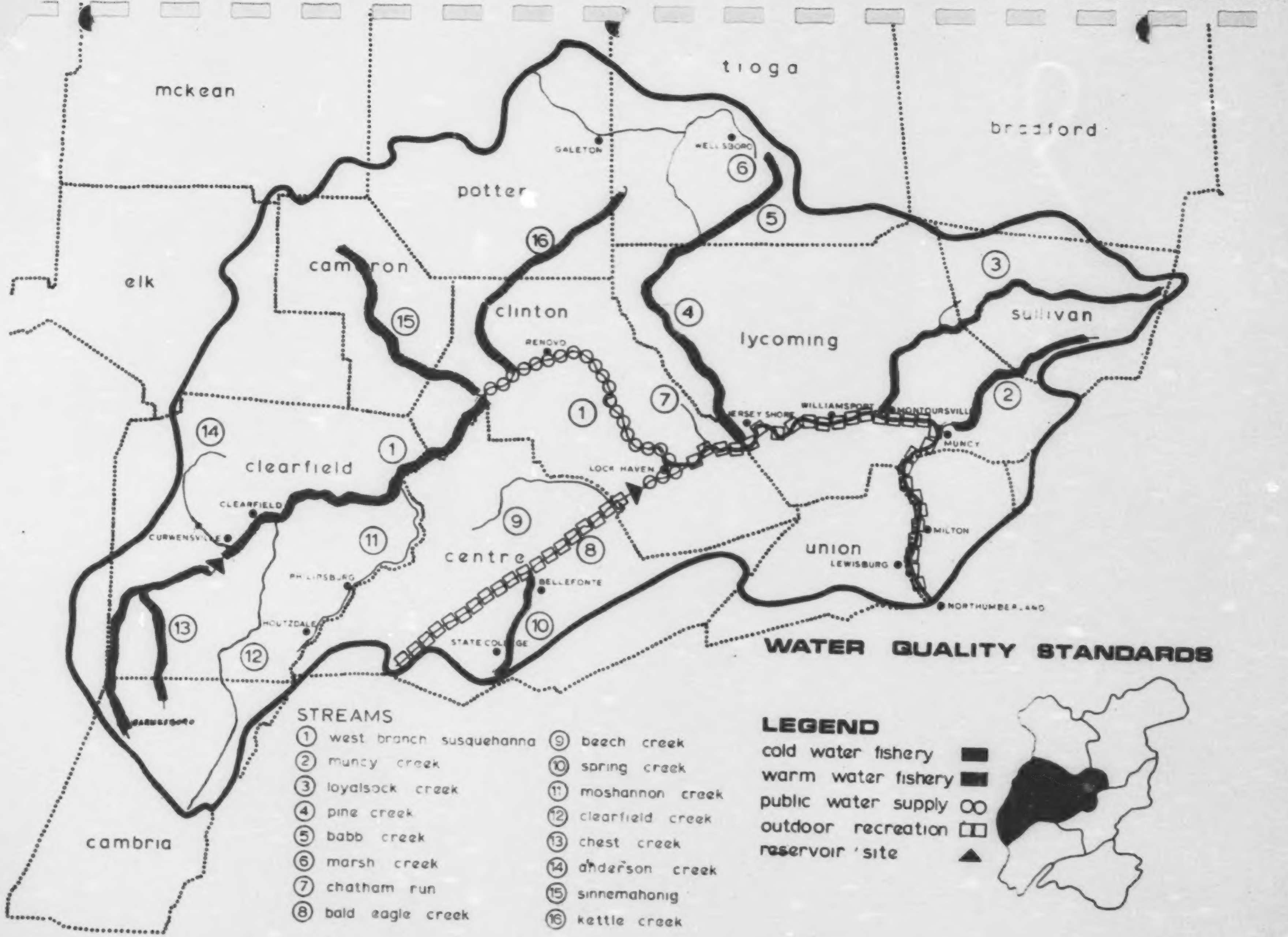
Although there is very little regional employment in forestry products, the thousands of acres of standing timber constitute a resource base for the development of wood and paper products.

Mining represented more than three percent of total employment in 1960 and was more important in this area than it was for the Susquehanna Basin as a whole as well as for the nation. Bituminous coal mining accounted for most of the employment, although anthracite coal, sandstone, clay, shale, and limestone are also mined in the area. Clearfield County leads in bituminous coal production and mining employment. It was one of the most severely affected by the decline in bituminous mining employment, with about a 60 percent decrease between 1947 and 1960.[1] Mining employment is expected to continue to decline in importance and will represent less than one percent to total employment by 2020.

[1] U.S. Bureau of Mines, Susquehanna River Basin: Preliminary Report on the Mineral Producing Industry of the area. March, 1963.

WATER QUALITY MANAGEMENT OBJECTIVES:

Present and Future Uses of Water


WATER QUALITY STANDARDS

Water Quality Standards

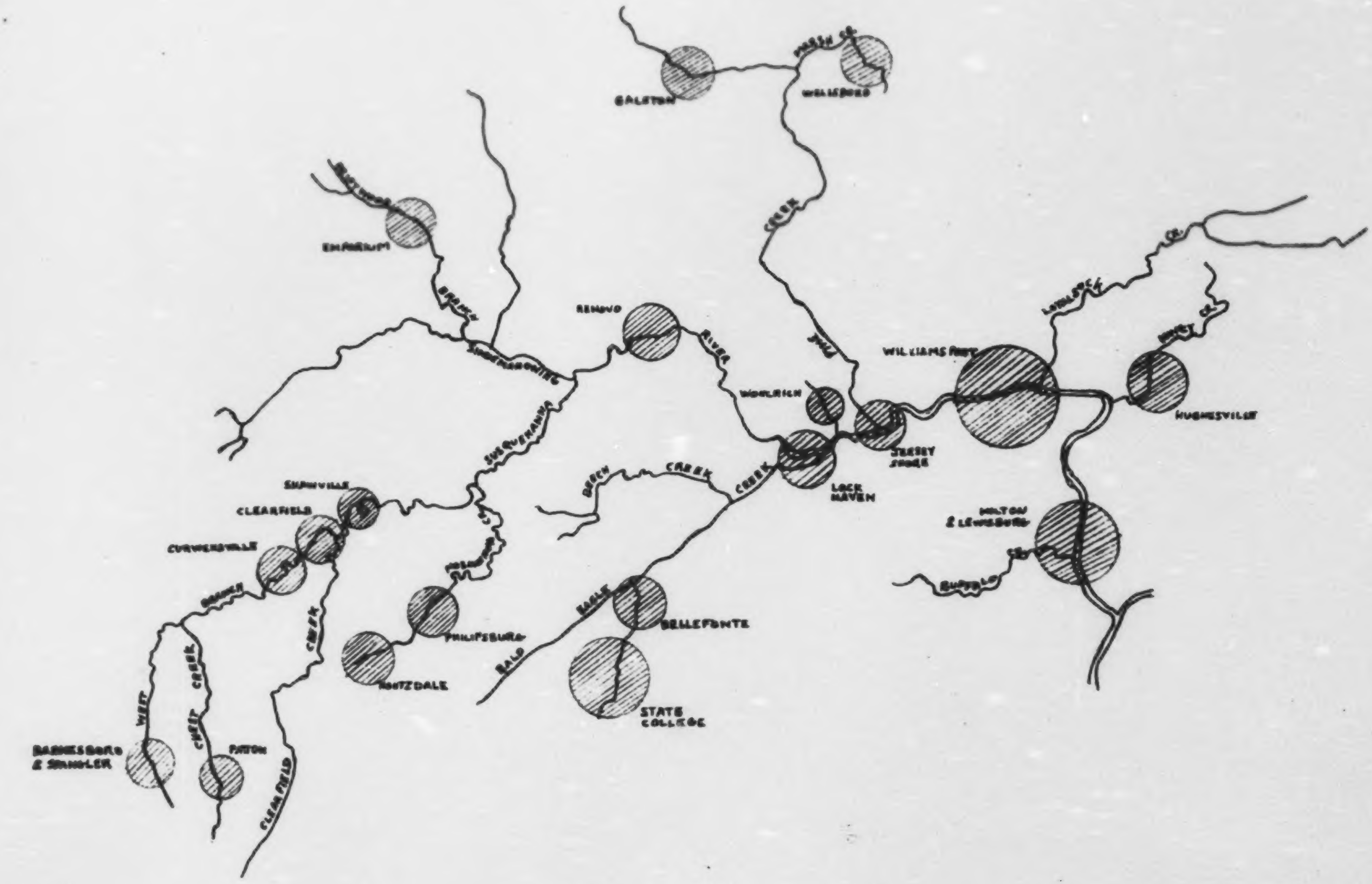
There are no interstate streams in the sub-basin, therefore, interstate water quality standards are not in effect. The state of Pennsylvania, however, does require maintenance of dissolved oxygen at 5.0 mg/l, which is to be maintained except in severe drought years that have a one-in-ten-year frequency. The state also requires secondary treatment of all wastes except where an acid impregnated stream is the receiving stream. Primary treatment (35 percent BOD removal) is considered satisfactory for these discharges until such time that the mine drainage situation is changed. When the acid condition becomes alleviated, however, secondary treatment must be instituted.

Recreational Uses

Recreation opportunities are abundantly provided by the waters of the sub-basin, although mine drainage pollution inhibits recreational activity in some locales. The market population exerting demands on the area's waters is 450,000 people, 50,000 in excess of the number actually in residence. There is expected to be increased demands on the part of people from outside the sub-basin as a result of Interstate Route 80, the "Keystone Shortway," which will provide direct access to this area for New York Metropolitan area residents.

There are over 1200 miles of streams and more than 2000 acres of lakes in the area. About 8400 acres, including streams and lakes, are considered to be accessible for public recreation. Currently, demands are estimated at four million water-oriented recreation user-days each year. With a doubling of the population by 2020, a corresponding increase in deficit of resource availability is anticipated.

WEST BRANCH SUSQUEHANNA
WATER SERVICE AREAS



Projected Recreation Uses

Target Year	Rec. Market Pop. (1000's)	Demand*		Supply*		Deficit in Water-Oriented Recreation
		Rec.	Boating	Rec.	Boating	
1980	634	8.50	1.52	7.93	1.46	0.57
2000	1000	15.75	2.62	9.11	1.70	6.64
2020	1220	23.60	4.16	10.72	1.94	12.88

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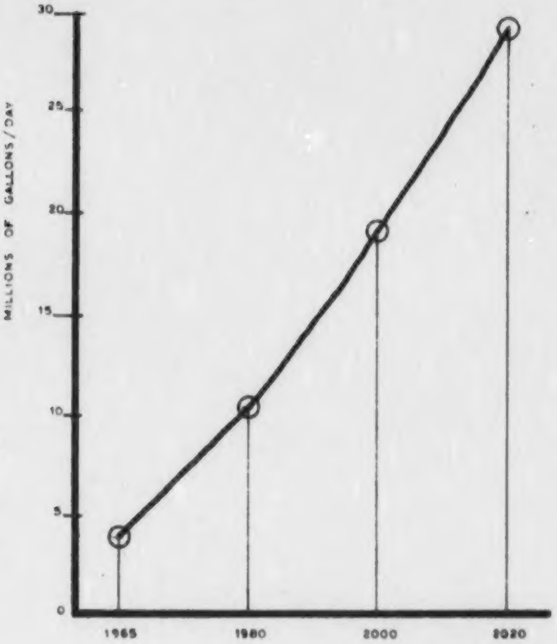
* Million days per year

About 40,300 fishermen use the waters of the sub-basin each year at a rate of 700,000 user-days and spend 3.4 million dollars on supplies and transportation. Most of the demand is exerted on cold water fisheries with 468,000 fishermen-days enjoyed on 1151 miles of trout waters. Fishermen also fish 34 miles (600 acres) of warm water fisheries. Many potential reaches of fisheries waters are rendered useless by mine drainage, however, and future pressures indicate that unless these are cleaned up a rather large recreational enterprise will be forfeited.

Year	Fishermen (1000's)	Fishermen Days/Year (Millions)	Annual Expenditures ($ Millions)
1980	73.9	1.42	6.3
2000	103.9	2.02	8.9
2020	119.8	2.16	10.5

Municipal and Industrial Uses

Municipal and industrial demands are met by 19 principal water service areas providing 88 million gallons of water each day to 243 thousand people. There is a three mgd diversion from the Anderson Creek headwaters providing the town of Dubois with water; this is the only significant diversion and the water from it ends up in the Allegheny Basin. Water supplies for most of the communities have been developed from mountain



water use projections for state college area tributaries where water quality is generally good. The State College area is supplied mostly from ground water and the future needs for this area are expected to increase seven-fold in response to increased population and industrial demands. For the entire sub-basin, total water usage will not increase as dramatically as it will for the State College area.

Year	Population Served (1000's	Municipal (mgd)	Industrial (mgd)	Total (mgd)
1965	243.2	23.7	64.8	88.5
1980	394.8	49.8	93.1	142.9
2000	555.5	83.0	128.5	211.5
2020	758.2	134.5	198.5	322.0

Irrigation Uses

Irrigation is not too great a demand on water resources in the West Branch sub-basin, with about 1220 acres irrigated annually. At present, water consumption is about 1700 acre-feet per year with an estimated instantaneous demand of 15 cfs. Most of the future irrigation is expected to take place along the West Branch itself between Lock Haven and the point of confluence with the main branch of the Susquehanna. The Department of Agriculture projections estimate that demands for irrigation out of surface water supplies will increase ten-fold by the year 2020. Present demands are greatest during the drought years and, by 2020, there will be an estimated 12,000 acres under irrigation with a water consumption in acre-feet of 16,700 and an instantaneous demand of 145 cfs.

Cooling Water Uses

Electric power is generated from two plants, both rather small in comparison to others in the Susquehanna Basin. However, each poses a threat to the streams which receive the cooling waters. The Pennsylvania Electric Company plant at Shawville, Pennsylvania, with an installed capacity of 595 MW, uses the West Branch as a source of cooling water and has a once-through cooling system requiring 650 cfs; this is the entire flow of the West Branch during low flow periods.

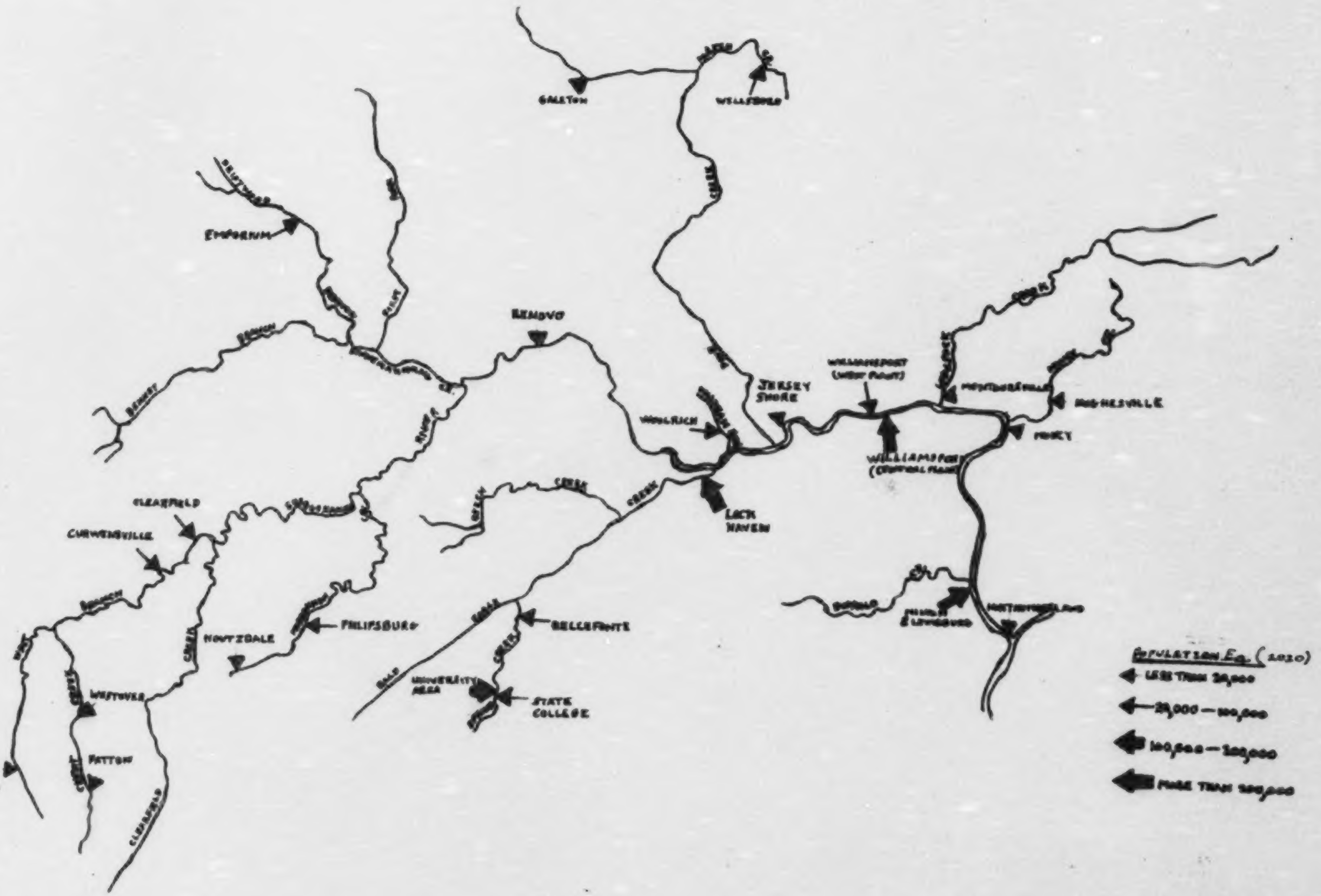
The West Penn Power Plant at Milesburg requires 149 cfs for its once-through cooling process; this quantity is a major portion of the creek supplying its cooling water.

SOURCES, PROBLEMS,

AND

POLLUTION ABATEMENT

WEST BRANCH SUSQUEHANNA
WASTE DISCHARGES



Sources of pollution were studied and evaluated. The table below summarizes the current conditions and specifies immediate pollution control needs:

Sewage Service Areas and Immediate Needs Summary

Sewage Service Area	Present Capacity (mgd)	Present Treatment Level	Immediate Treatment Level Needs* (Dec. 1968)	Max. Allowable BOD Discharge (lb/day)
Barnesboro-Spanger	---	None	Secondary	350
Patton	---	"	"	200
Westover (incl. Westover Tannery)	0.2	Secondary	"	800
Curwensville	0.5	Primary	"	1400
Clearfield	4.5	"	"	1800
Houtzdale	---	None	"	200
Philipsburg	---	"	"	800
Renovo	---	"	"	2500
Galeton	0.4	Primary	"	400
Wellsboro	0.8	Secondary	Increase capacity Advanced	200
Jersey Shore	0.8	Primary	Secondary	2000
Williamsport (West Plant)	1.3	"	"	1500
Williamsport (Central Plant)	5.1	"	"	7600
Montoursville	---	None	"	500
Hughesville	---	"	"	300
Milton-Lewisburg (incl. Chef Boy-ardee Plant)	2.6	Primary	"	300,000
Northumberland	0.6	"	"	5,000
State College	4.0	Advanced	Advanced	200
University Area	4.0	"	"	500
Bellefonte	1.8	Secondary	"	500
Lock Haven	21.5	Primary	Secondary	6,000
Muncy	0.3	"	"	5,000
Emporium	0.5	Secondary	---	---
Woolrich	1.0	"	---	---

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* Pennsylvania requires primary treatment for discharges to acid impregnated streams. As the acid pollution is abated, secondary treatment will be required.

The following sections present an evaluation of sources, problems, and describe the necessary pollution abatement action to alleviate pollution. These actions have been developed with due respect for the anticipated growth and development of the sub-basin.

SOURCES AND PROBLEMS

Municipal and Industrial

There are about 174,000 people whose wastes are carried away by sanitary sewers at the present time. About 26,500 people have collection facilities that discharge directly to receiving streams without treatment. Primary treatment facilities now in operation receive wastes from about 100,000 people, and secondary treatment facilities treat wastes from more than 40,000 people. The remaining 179,000 residents of the hydrologic area use on-lot treatment facilities.

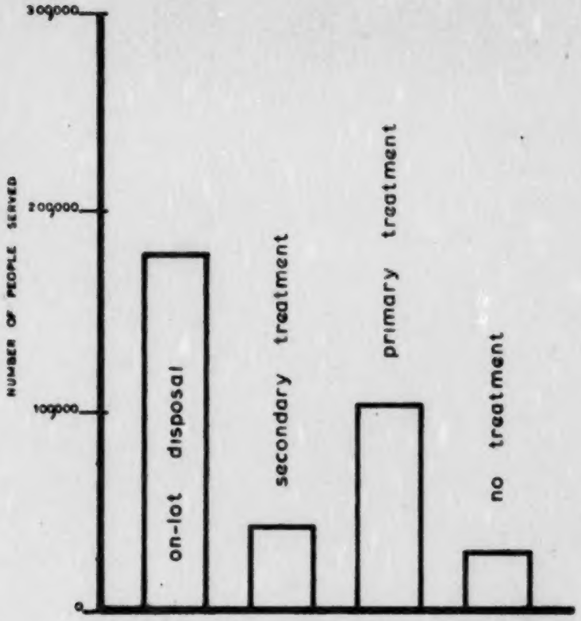
There are three large industrial operations in the West Branch sub-basin that release significant waste discharges. One of the plants is a leather tannery, the second a paper mill, and the third a food processing plant run by the Chef-Boy-Ardee Company in Milton. Due to the lack of adequate facilities for waste treatment, this Chef-Boy-Ardee plant discharges a heavy organic load to the West Branch. Howes Tannery in Curwensville produces sole leather only and discharges lime, hair, flesh particles, tanning liquors, and acid to the West Branch. Its treatment facilities are considered to be inadequate for the amount of waste produced. Hammermill Paper Company at Lock Haven provides only primary treatment of its wastes.

The population equivalents of waste produced by all West Branch industries total nearly 106,000 before treatment. About 60,000 are discharged after treatment.

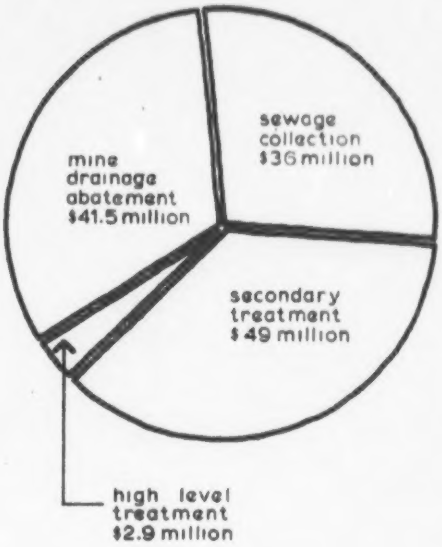
The total loading in population equivalents, including that from industrial establishments, is 550,000. Of these, about 459,000 are discharged after primary treatment and 50,000 are represented by the effluent from secondary treatment plants. About 40,000 population equivalents are discharged into the streams with no treatment whatsoever.

After treatment, the waste load discharged is equivalent to raw waste from a population of 346,000.

breakdown of treatment methods (1968)



costs of recommended abatement measures (1965 - 1980)



Municipal and Industrial Wastes

In the West Branch drainage area about 174,000 people are now being served by sanitary sewers. By 2020 it is projected that 758,600 people will receive sanitary waste service. Sewage collection cost estimates are projected as follows.

Estimated Capital Needs for Sewage Collection

Time Period	Total Population Served 1000's	New Population Served 1000's	Estimated Cost $ Million
1965	168.4	---	---
1965-1980	342.2	173.8	36
1980-2000	493.4	151.2	52
2000-2020	758.6	265.2	61

All 24 sewer service areas should achieve secondary treatment as a minimum (see immediate needs table). However, communities which discharge directly to acid impregnated streams will only be required to provide primary treatment until the acid pollution is abated. Capital needs to achieve and maintain secondary treatment are described below.

Time Period	1000's Pop. Served		Estimated Capital Needs $ Millions
	Population	Population Equiv.	
1965-1980	342	1167	49
1980-2000	493	1934	40
2000-2020	758	3291	37

Lock Haven industrial and municipal wastes, including the Hammermill Paper Company, should be combined into one system, conveyed to a secondary treatment plant, and the effluent piped to the Bald Eagle-West Branch confluence. It is necessary, however, that feasibility studies be undertaken to investigate alternative solutions to this before action is begun.

The Howes Tannery and the Curwensville service area should provide a minimum of secondary treatment in the immediate future. The Chef-Boy-ardee Plant in Milton and the Milton-Lewisburg sewage service area should also provide a minimum of secondary treatment in the immediate future.

Three urban areas need to employ high level BOD and nutrient removal processes to meet intrastate water quality standards. These areas are State College, (including the greater University area), Bellefonte and Wellsboro.

State College already has a treatment facility operating at greater than 90 percent efficiency for BOD removal. In addition, about 10 percent of the waste flow is conveyed to a spray irrigation project, which virtually disposes of all the organic and nutrient pollutants. This kind of land application is recommended for all the wastes of the State College area to reduce nutrient loading to Spring Creek.

The following table summarizes the total costs of all recommended treatment facilities including high level BOD removal. Costs do not include associated collection facilities.

Total Costs of Recommended Treatment Facilities*

Time Period	1000's Population Equivalents Received	1000's Population Equivalents Discharged	Estimated Capital Needs $ Millions
1965	550	346	
1965-1980	1167	164	52
1980-2000	1934	276	45
2000-2020	3291	423	51

* Costs do not include nutrient removal.

SOURCES AND PROBLEMS

Mine Drainage

The West Branch contains the major portion of the bituminous mine drainage problem of the Susquehanna system. Significant acid loadings originate in 15 upstream watersheds, contributing an estimated 484,000 pounds of acid per day. Iron, in pounds per day, amounts to 165,000.

Principal Receiving Stream	Acid Flow (cfs)	Acid Load at Sources (lb/day)	Iron (lb/day)
Upper West Branch	19.7	53,500	23,000
Chest Creek	7.9	8,300	2,200
Anderson Creek	3.1	7,300	1,500
Clearfield Creek	44.0	45,200	12,900
Congress Run	1.1	11,400	2,000
Deer Creek	2.2	15,400	2,400
Sandy Run	1.1	10,000	1,250
Alder Run	4.0	18,000	1,450
Moshannon Creek	146.9	135,200	76,200
Sinnemahoning Creek	10.9	32,900	5,400
Cooks Run	1.2	13,100	1,800
Kettle Creek	6.5	28,500	7,300
Beech Creek	13.3	21,700	4,500
Babb Creek	8.1	14,800	1,200
Loyalsock & Minor Tribs.	43.8	68,600	21,900
Total	313.8	483,900	165,000

ABATEMENT

Mine Drainage

The most feasible solution for control of pollution associated with mining activities in the West Branch includes a combination of physical preventive measures followed by chemical treatment of acid discharges. Preventive measures include reconstructing stream channels, excavating and restoring subsided areas, covering refuse material, backfilling selected strip mine areas, and constructing surface water diversions at selected locations. Chemical treatment through lime neutralization is considered to be the most feasible means of removing the remaining acid loads discharged to the streams of this area. The following estimate indicates mine drainage pollution abatement costs in the West Branch.

General Costs of Abatement

Watershed	First Cost - (Millions) Prevention Measures	Collection & Treatment	Total 1st Cost	Avg. Ann. Cost. (1000's)	Opr. & Maint. (1000's)
Miscellaneous	0.09	21.55	21.64	---	---
Upper West Branch	11.20	6.95	18.32	2,040	1,017
Chest Creek	1.44	1.35	2.79	379	220
Anderson Creek	0.65	0.47	1.12	158	95
Clearfield Creek	5.50	5.52	11.03	1,625	1,010
Congress Run	1.32	0.38	1.70	208	113
Deer Creek	1.84	0.49	2.33	276	146
Sandy Run	1.27	0.33	1.46	180	98
Alder Run	2.09	0.64	2.74	321	169
Moshannon Creek	22.72	25.55	52.60	11,550	3,071
Sinnemahoning Creek	3.67	1.80	5.48	768	462
Cooks Run	0.71	0.35	1.06	147	87
Kettle Creek	1.44	1.38	2.73	415	261
Beech Creek	2.19	1.87	3.96	537	313
Babb Creek	0.68	0.99	1.67	262	168
Loyalsock Creek	0.26	0.17	0.43	117	94
Total	57.07	69.79	126.86	18,983	7,324

Treatment measures are considered supplemental to initial preventive measures and are designed to take care of the excess flow of acid during periods of heavy rainfall. Treatment facilities were designed on the basis of the once-in-ten-years expected heavy rainfall. Lime neutralization was used for estimating treatment costs because it is the least expensive of methods presently operational.

In each case, the estimates reflect an optimum mix of preventative measures followed by treatment of acid remaining after preventative measures. Costs reflect total abatement.

Costs of Lime Neutralization

	Treatment Costs (Millions)		
Watershed	First	Total Annual	Annual Oper. & Maint.
Upper West Branch	2.61	0.169	0.837
Chest Creek	0.66	0.232	0.193
Anderson Creek	0.26	0.100	0.085
Clearfield Creek	2.90	1.068	0.908
Congress Run	0.28	0.119	0.100
Deer Creek	0.30	0.117	0.100
Sandy Run	0.24	0.103	0.088
Alder Run	0.27	0.206	0.175
Moshannon Creek	6.81	2.440	2.118
Sinnemahoning Creek	0.84	0.461	0.414
Cooks Run	0.26	0.096	0.081
Kettle Creek	0.95	0.056	0.056
Beech Creek	0.65	0.309	0.263
Babb Creek	0.30	0.163	0.146
Loyalsock Creek	0.15	0.100	0.090

MISCELLANEOUS WATER QUALITY
PROBLEMS

SOURCES AND PROBLEMS

Nutrients

Nutrient pollution is a significant source of water quality degradation in the West Branch sub-basin. During the summer months excessive algae and aquatic weed growths occur in Spring Creek below the State College municipal complex, in North Bald Eagle Creek below Bellefonte, in Marsh Creek below Wellsboro, and in the West Branch below the cities of Lock Haven, Williamsport, and Lewisburg.

Combined Sewers

Combined sewers exist in eight communities in the sub-basin: Spangler, Clearfield Jersey Shore, Williamsport, and Lewisburg in the West Branch; Philipsburg on Moshannon Creek; Galeton on Pine Creek; and Wellsboro on Marsh Creek. Although the discharges from these sewers periodically degrade the receiving streams, the extent of organic and nutrient loadings coming from combined sewers has not been evaluated.

Individual Waste Disposal Systems

There are presently 178,600 people using on-lot waste disposal systems in this sub-basin. By 1980, this figure is expected to increase to 234,700 and to 240,700 by 2020. Periodic failures of these systems cause locally severe water quality problems.

Thermal Pollution

The Pennsylvania Electric Company's Shawville Plant, on the West Branch, poses the only serious thermal pollution threat in the sub-basin. It requires about 650 cfs of cooling water, constituting all of the flow of the stream, during low flow periods. This results in a complete thermal barrier within the river. However, the river is already badly degraded by mine drainage at this point, thus masking any damages attributable to the heated discharge.

The West Penn Power Company has a 46 MW plant at Milesburg which discharges heated water to Spring Creek near its junction with the Bald Eagle Creek. It uses up to 149 cfs of water which constitutes a significant thermal load to Bald Eagle Creek.

ABATEMENT

Nutrients

Nutrient removal at State College is required by the Pennsylvania Sanitary Water Board. Nitrate and phosphate removal will probably be needed at Bellefonte and Wellsboro, Lock Haven, Williamsport, and the Milton-Lewisburg areas. Studies should be continued to determine the levels of phosphorus and nitrogen in the streams and to identify stream reaches where these nutrients are the cause of water quality degradation.

Combined Sewers

Numerous methods of eliminating the adverse effects of combined sewer discharges are currently under intensive study, but at the present, no economically feasible method is available for abating the pollution from this source. Until a practical solution is found, it is assumed that existing combined sewers will continue to be used. It is recommended that no new combined sewers be built.

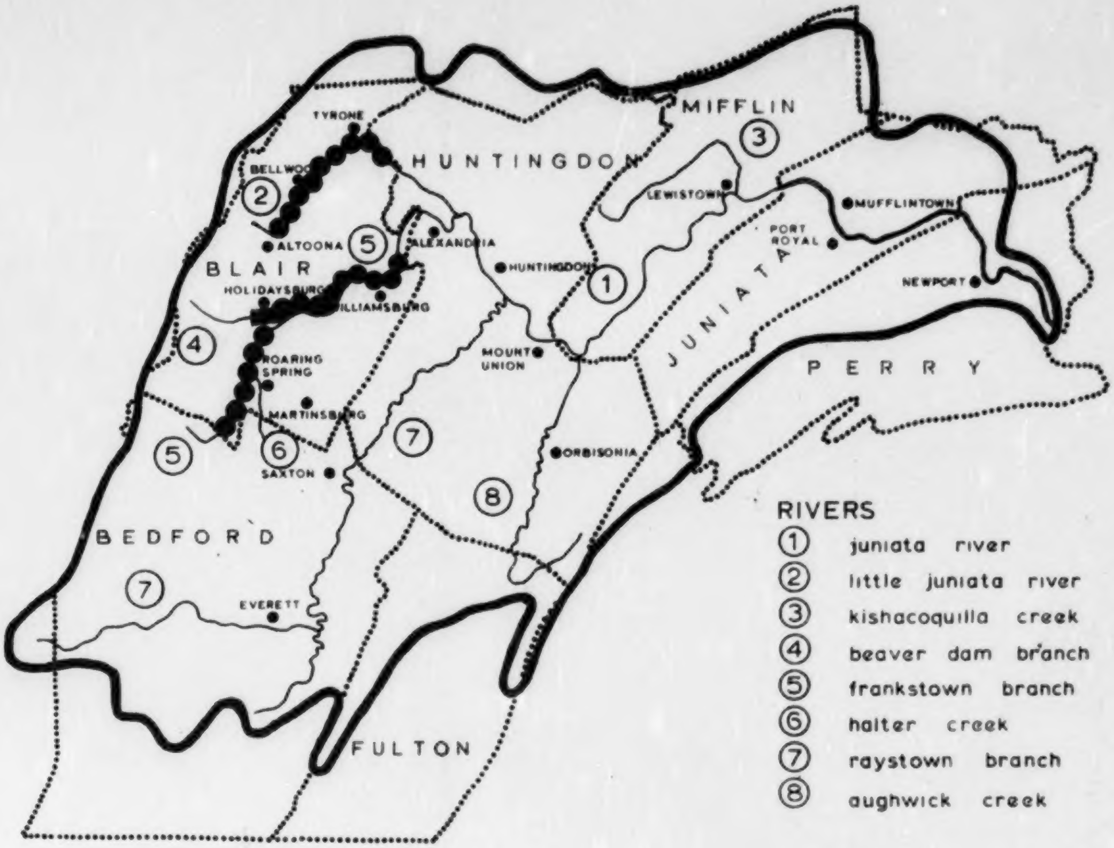
Individual Waste Disposal Systems

It may not be feasible for all rural populations to connect with regional collection facilities. Pennsylvania administers laws regarding septic tank usage where tank capacity and drain field construction vary with soil type, lot size, and living-quarters capacity. These kinds of facilities can be very efficient when properly designed and maintained, but wherever possible, people are encouraged to connect into a regional collection system.

Thermal Pollution

The Shawville plant of the Pennsylvania Electric Company should install a closed forced cooling system concurrent with mine drainage abatement on the West Branch.

The West Penn Power Company should install forced cooling facilities for its Milesburg plant.



JUNIATA

LEGEND

mine drainage degradation.... ▬

organic degradation .... ●●●●

General Description

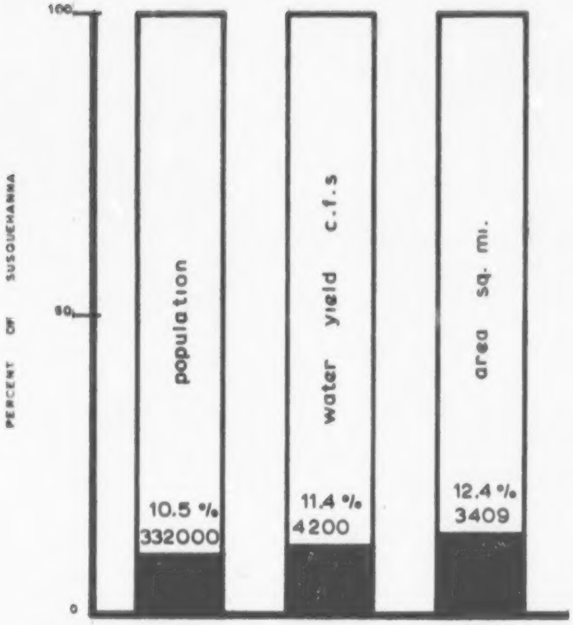
The Juniata watershed is characterized by long mountain ridges and narrow valleys. About 66 percent is covered by forests while much of the remainder is used for grassland farming. The streams are naturally swift and turbulent, but tend towards low flow conditions during the late summer and early fall.

The Juniata sub-basin is entirely within the Appalachia Region of Pennsylvania and has experienced negative economic growth since the early 1950's. In 1965, the population was about 332,000 with about half the residents living in urban communities. The population of this sub-basin is expected to increase to 650,000 by 2020.

For purposes of this study, the Juniata was divided into 15 principal water service areas to determine current municipal and industrial usage and to predict future concentrated demands on surface water supplies. It was divided into 23 principal sewage service areas to determine current waste handling and sewage treatment practice, and to predict future water quality needs.

Organic pollution is a severe problem on the Little Juniata River and the Frankstown Branch. The organic pollution arises mainly from Altoona on the Little Juniata and from Roaring Spring on the Frankstown Branch. The organic problem is compounded by BOD loads and severe discoloration caused by the waste from pulp and paper operations. There are six principal tributaries of which only three are unpolluted: Spruce Creek tributary, Aughwick Creek, and Tuscorora Creek. One other, the Raystown Branch, is basically a good quality stream, but it too has organic and nutreint loadings in the locale of Bedford-Everett. The Little Juniata and the Frankstown Branch are grossly

percent of total susquehanna basin



polluted with organic waste and pose the greatest problems in the sub-basin.

Nutrient enrichment is considered to be a minor problem in this sub-basin, with most of the problem being associated with municipal waste discharges. Algae growths have been observed in the Beaverdam Branch and Raystown Branch.

Fourteen sewage service areas need to install or upgrade their waste handling facilities to secondary treatment. Five sewage service areas will needed to utilize some form of high level BOD removal to maintain the minimum 5.0 mg/1 dissolved oxygen objective of the water quality standards. These areas are southwest Altoona, northeast Altoona, Tyrone, Roaring Spring, and Williamsburg.

Mine drainage pollution is not considered serious in this sub-basin, however, 32 square miles of the total land area has been disturbed by mining operations. Tributaries arising from these areas contribute about 18,000 pounds of acid per day to the waterways of the sub-basin. A combination of preventive measures and treatment of mine drainage as needed for control of acid discharges in three watersheds in this sub-basin.

An understanding of the surface and ground water resources is basic to water quality management programs in keeping with both quantity and quality for the various uses to be made of this resource.

Waste assimilative capacities of the streams of the sub-basin are a function of flow and temperature during the critical summer season from July through October. Major tributaries of the sub-basin, as shown in the following table, exhibit wide flucturations of stream flow and clearly indicate the effects of drought conditions during the summertime on dependable stream flow. These fluctuations must be considered in delineating water quality management programs for the water service areas of the sub-basin. Waste assimilation flow needs were based on stream flow conditions expected to recur once-in-20-years.

Stream Flow Characteristics at Selected Locations

Stream and Gauge*	Instantaneous Flow Extreme Max.	Instantaneous Flow Extreme Min.	Mean An. Flow	August Flow Data Mean Flow	August Flow Data 1-in-20-yr. Low Flow	August Flow Data Minimum Daily Flow
Frankstown Br. at Williamsburg, Pa.	47,600	13	383	145	59	47
Little Juniata R. at Tipton, Pa.	5,700	9.4	149	51	18	16
Little Juniata R. at Spruce Cr.	23,100	45	354	132	78	76
Juniata River at Huntingdon, Pa.	34,200	14	1,031	436	211	188

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* Data collected by U.S. Geological Survey (all measurements are stated in cfs.)

There is only one man-made impoundment of any importance, the Shawnee Reservoir in Bedford County. Its total surface area is 451 acres and the water in it is considered to be of good quality. Another impoundment, Little Buffalo Reservoir in Perry County, is currently under construction. When completed the reservoir pool will have a surface area of 105 acres and the impounded water is expected to be of good quality.

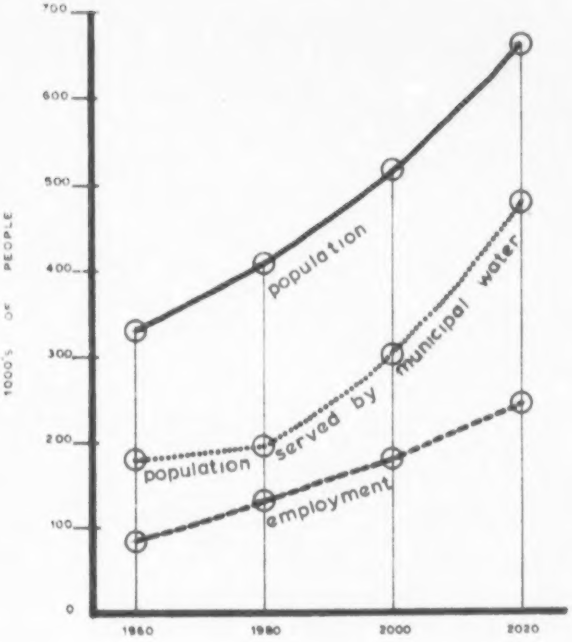
Economic Base

This economic subregion includes portions of the Pennsylvania counties of Bedford, Blair, Huntingdon, Juniata, Mifflin, Perry, and Snyder and its population represents about 10.5 percent of the 1960 total for the Susquehanna Basin; it is projected to grow slowly in relation to the nation and the basin, increasing about 36 percent between 1960 and 1990 and about 100 percent between 1960 and 2020. A significant portion of the population growth will be associated with the urban centers of Bedford, Lewistown, Altoona, and Huntingdon.

Manufacturing accounted for about 26 percent of the total employment in 1960. This was lower than the percentage so employed throughout the basin, but about equal to the national average. Employment in manufacturing is projected to grow very slowly through 1990 but to fall therafter, indicating the competitive disadvantage of the area in relation to the rest of the basin and the nation. The industry employing the greatest number of people in 1960 was the apparel manufacturing industry which accounted for about 4,500 jobs that year.

Employment in fabricated metals, transportation equipment, printing and publishing, and instruments is projected to grow rapidly by 1990. However, this represents only an absolute increase of less than 2,000 new jobs. The electrical and non-electrical equipment industries are projected to grow moderately, partly as a result of low labor costs within the area. However, total manufacturing employment will decline after 1990.

Nonmanufacturing employment is forecast to grow more slowly within this subregion than in any other of the five areas. Fairly rapid growth



population & employment trends

is expected in construction, wholesale trade, finance, government, and services as income and population increase, with government and service sectors constituting a smaller percentage than throughout the basin.

In 1960, agricultural employment was about eight thousand, more than eight percent of total employment. Its importance will decline and by 2020 it will represent about four percent.

Mining employs a small percentage of the total and is expected to continue declining. Coal, sandstone, lime, clay, and gravel are mined in this sub-basin.

The Penn-Central Repair Shop at Altoona serves to bolster employment in the transportation sector so that it is, and will continue to be, a greater percentage of total employment than it is for the basin as a whole and the nation.

Per capita income levels will continue to be below that for the entire basin; in terms of the 1960 dollar, it will rise from 1,800 in 1960 to 10,000 in 2020.

In 1960, about 11 percent of total employment was associated with the major water using industries. The level of employment for this industrial grouping is forecast to decline by 1990, primarily because of the expected contraction in textile and chemical employment. The job levels in the other industries are expected to remain stable or grow moderately.

The following table gives the percent change in total output from 1960 to 1990 for the large water using industries.

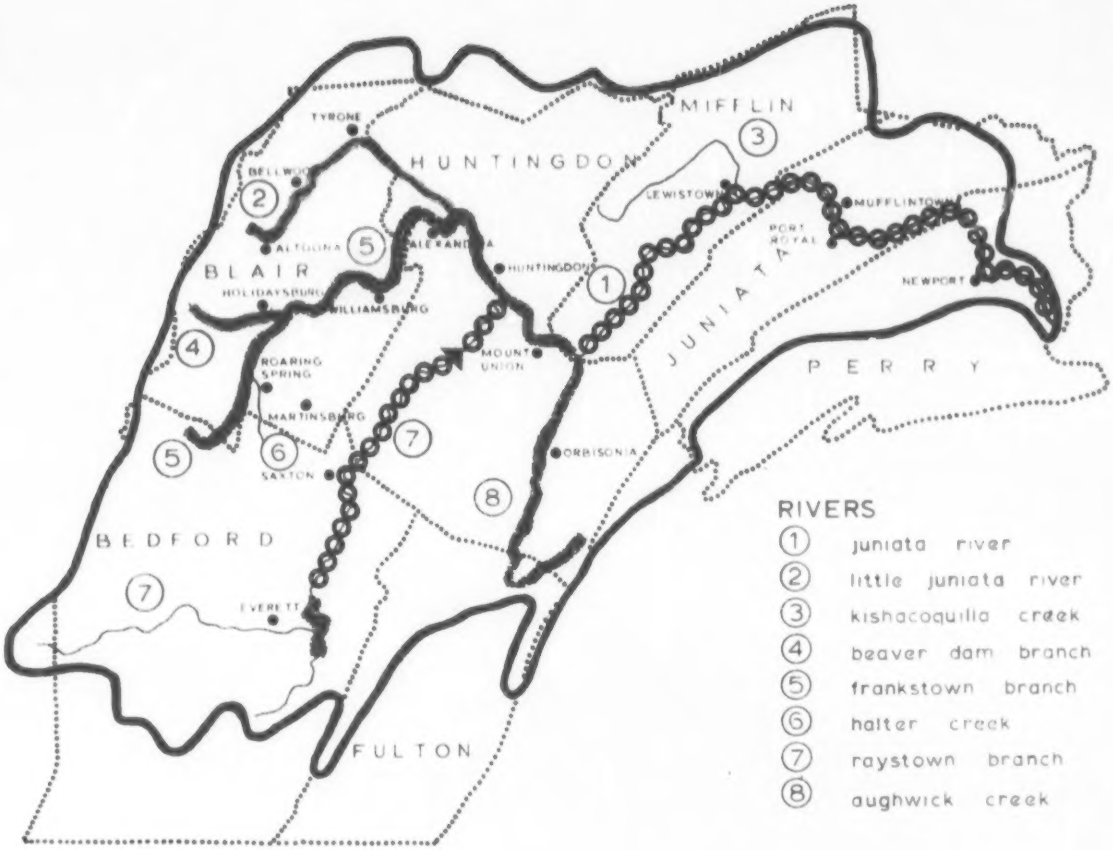
Projected Growth in Output for Major Water Using Industries
(in percent)

	1960 to 1970	1960 to 1980	1960 to 1990
Food	57	134	246
Textiles	21	46	35
Paper	45	108	171
Chemicals	32	101	199
Primary Metals	28	73	135

Population and industrial growth projections as summarized above were used to project future waste loadings for the Juniata sub-basin.

WATER QUALITY MANAGEMENT OBJECTIVES

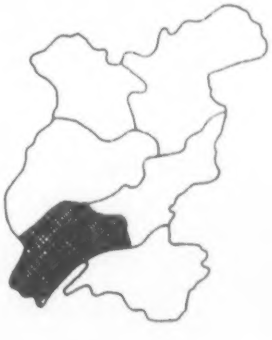
Water Quality Standards and Present and Future Uses of Water



RIVERS

① juniata river
② little juniata river
③ kishacoquilla creek
④ beaver dam branch
⑤ frankstown branch
⑥ halter creek
⑦ raystown branch
⑧ aughwick creek

WATER QUALITY STANDARDS



LEGEND

cold water fishery .... ▬
warm water fishery ...... ▬
public water supply....... oooooo
outdoor recreation .... ▭▭▭▭▭▭
reservoir site .... ▲

Water Quality Standards

All the streams in this sub-basin, as in the West Branch sub-basin are intrastate streams. Judging by the intrastate standards set elsewhere in the state of Pennsylvania, the state will require secondary treatment of all waste discharges except where the receiving stream is overwhelmed by mine drainage. In these cases, primary treatment will be required. The minimum dissolved oxygen objective is a concentration of 5.0 mg/l dissolved oxygen.

Recreation Uses

Recreation uses of the waterways in this sub-basin are high but there appears to be an ample supply of recreation opportunity to meet current demands. The market population exerting demand on the area's waters is 300,000 people, about 45,000 in excess of the population actually in residence. There are 254 miles of streams and 670 acres of lakes open to them and currently annual usage is estimated at two million water-oriented recreation days and 600,000 boating days per year.

Projected Recreation Uses

Target Year	Rec. Market Area Pop. (1000's)	Demand*		Supply*		Deficit in Water-Oriented Rec.*
		Rec.	Boating	Rec.	Boating	
1980	410	4.19	0.67	5.03	0.79	---
2000	484	7.59	1.17	5.83	0.92	1.76
2020	810	12.36	1.84	7.03	1.03	5.33

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* Million days per year

About 27,400 fishermen use the waters of the Juniata sub-basin at the rate of 500,000 user-days a year. It is estimated that they spend 2.3 million dollars on supplies, bait, and transportation. About 178,000 user-days per year are devoted to fishing for trout on about 725 miles of trout streams. There are also about 1720 acres of warm water fisheries. These are sufficient to meet demands through 1980, but there will be deficits of 1.76 and 5.33 million user-days per year in water-oriented recreation for 2000 and 2020, respectively. These figures were derived with the Raystown Branch impoundment taken into consideration as a large recreational facility of the future.

Year	Fishermen (1000's)	Fisherman Days/Year (Millions)	Annual Expenditures ($ Million)
1980	40.1	0.77	3.4
2000	55.7	1.08	4.8
2020	79.4	1.43	7.0

Municipal and Industrial Uses

Municipal and industrial water needs are supplied by 15 water services in the sub-basin providing about 184,000 people with 70 million gallons per day. There are no diversions into or out of the sub-basin and water supplies for all the communities have been developed from mountain tributaries where water quality is generally good.

Altoona faces a possible water shortage by 1980 unless new sources of water are developed:

Year	Pop. Served (1000's)	Municipal Water*	Industrial Water*	Total Water*
1965	183.8	24.1	46.3	70.4
1980	195.6	36.5	53.7	90.2
2000	299.1	58.7	69.4	128.1
2020	466.9	95.5	86.6	182.1

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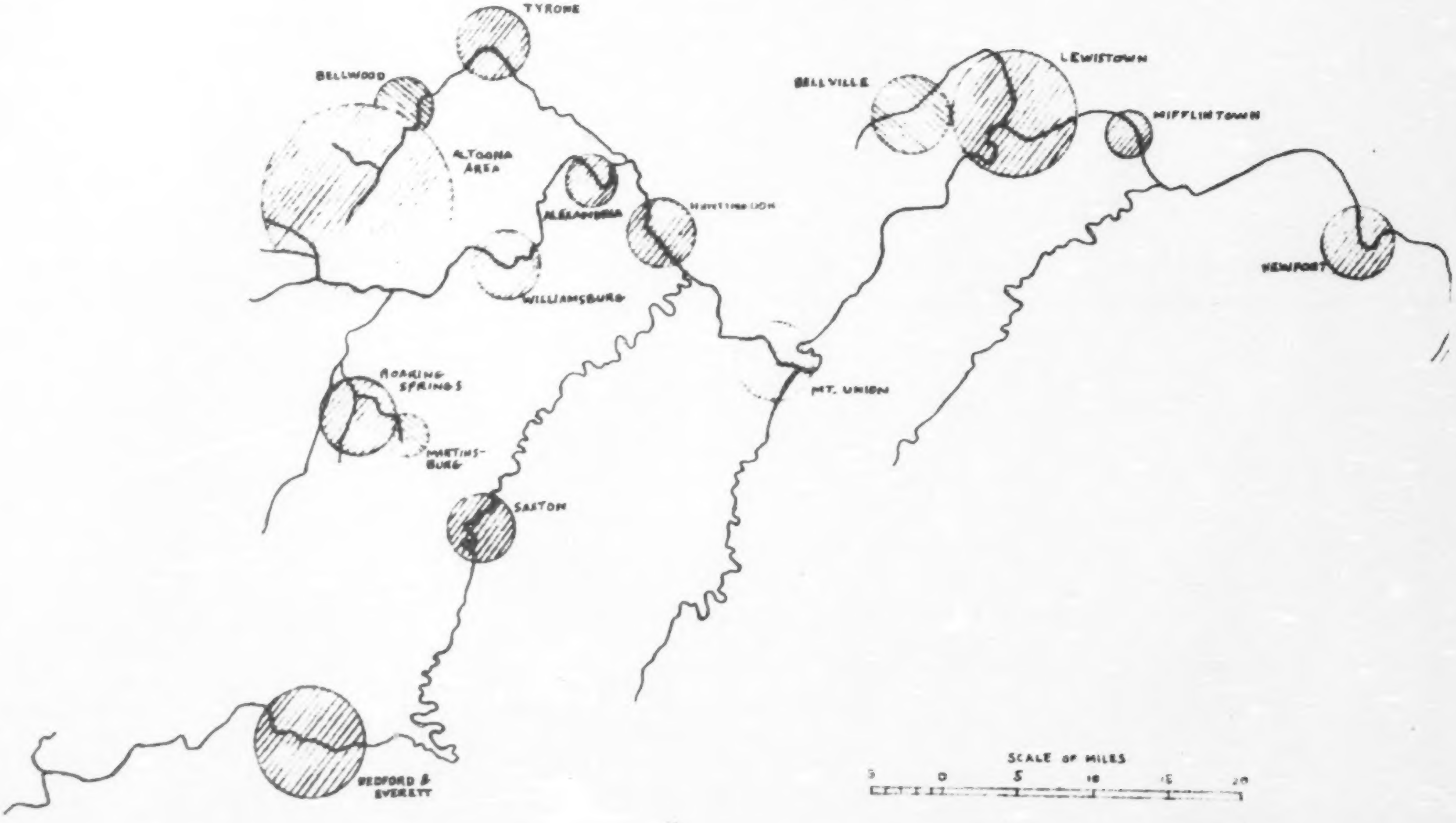
* mgd

JUNIATA RIVER
WATER SERVICE AREAS



Irrigation Uses

Irrigation is not significant in the Juniata sub-basin and any that will take place will occur along the Juniata River below Huntingdon and Lewistown. The Department of Agriculture has made projections through the year 2020 for possible drought demands for irrigation uses and these are listed below.

Irrigation Demands

Year	Est. Acres Irrigated	Water Consumption (Acre Ft.)	Est. Maximum Instantaneous Demand (cfs)
1965	1880	2500	19
1980	2030	2700	21
2000	3460	4600	41
2020	4810	6400	58

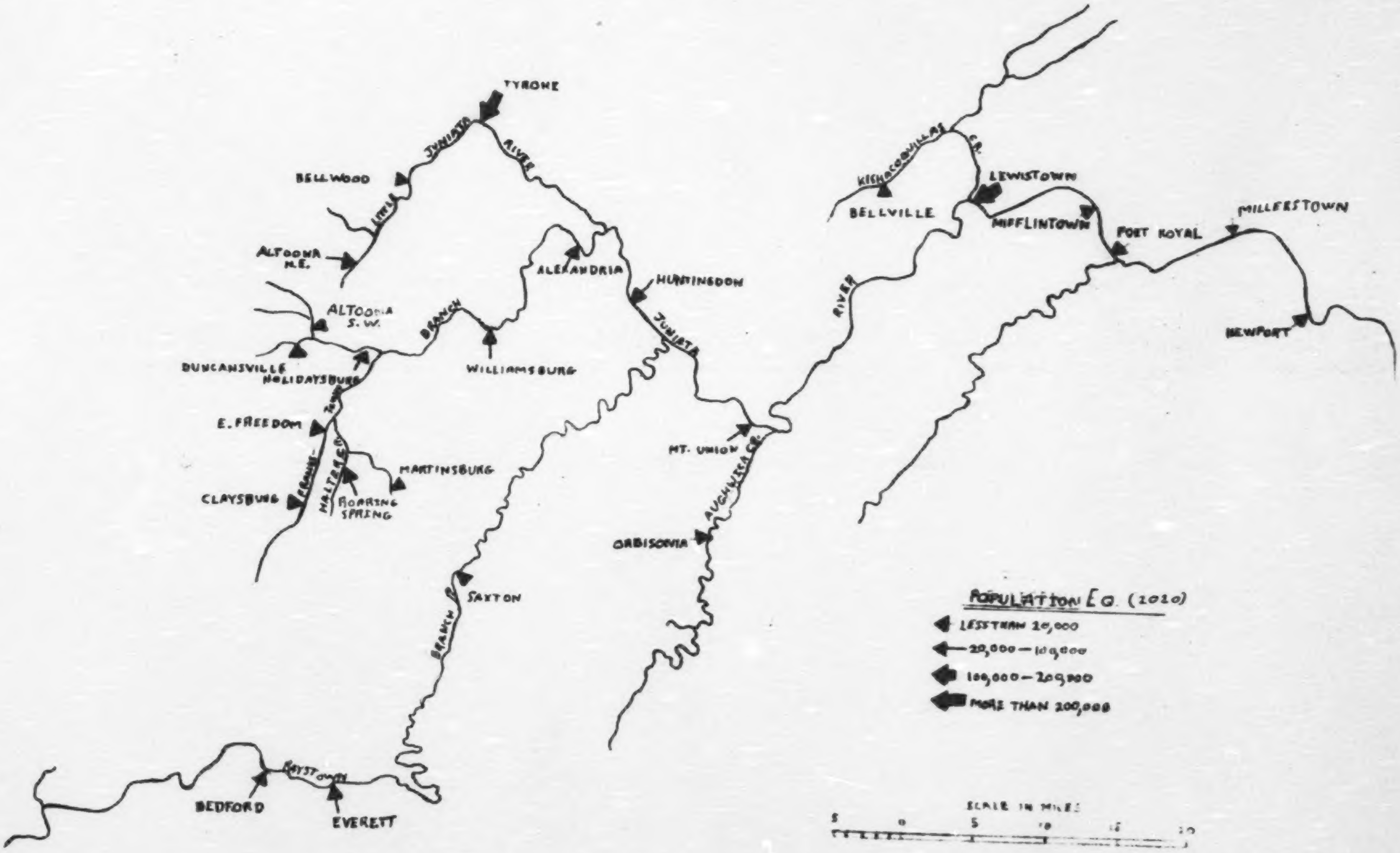
Cooling Water Uses

Electric power generation is presently confined to steam plants at Williamsburg and Saxton; the plant at Saxton is atomic powered. The installation at Williamsburg has a capacity of 45.2 MW and its cooling water source is the Frankstown Branch. The Saxton plant uses water from the Raystown Branch and its capacity is 50 MW. Both plants recirculate cooling waters and therefore pose no thermal pollution threat.

Sources of pollution and the associated problems were evaluated with the result that specific pollution abatement actions have been determined. The following table summarizes the current conditions in sewage service areas and identifies immediate pollution control needs.

SOURCES, PROBLEMS, AND POLLUTION ABATEMENT

JUNIATA RIVER
WASTE DISCHARGES



SEWAGE SERVICE AREAS AND IMMEDIATE NEEDS SUMMARY

Sewage Service Area	Present Capacity (mgd)	Present Treatment Level	Immediate Treatment Level Needs (Jan. 1969)	Max. Allowable BOD Discharge (lb)
Altoona (N.E. Plant)	5.5	Secondary	Secondary	850
Tyrone (incl. Westvaco)	8.5	"	Advanced* Color removal	3000
Roaring Spring (incl. D.M. Bare Pulp & Paper Co.)	5.5	"	Advanced* Color removal	1400
Altoona (S.W. Plant)	6.5	"	Advanced	600
Williamsburg (incl. Westvaco	4.5	"	Advanced* Color removal	600
Alexandria	---	None	Secondary	2000
Huntingdon	2.4	Primary	"	5000
Everett	0.2	"	"	500
Bedford	0.5	"	"	600
Saxton	---	None	"	1000
Orbisonia	---	"	"	500
Mt. Union	0.4	Primary	"	6000
Belleville	---	None	"	350
Lewistown	4.1	Primary	"	6000
Mifflintown	0.2	"	"	6000
Port Royal	0.2	"	"	6000
Millerstown	0.2	"	"	6500
Newport	0.3	"	"	7000
Bellwood	0.6	Secondary	----------	----
Southern Blair Co.	---	**	Secondary	----
Martinsburg	0.3	Secondary	----------	----
Duncansville	0.3	"	----------	----
Hollidaysburg	1.3	"	----------	----

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* High rate BOD removal.

** On-site disposal.

The following sections present an evaluation of sources, problems, and the necessary pollution abatement actions required to maintain water quality. The recommendations are based on anticipated growth and development of the Juniata sub-basin.

SOURCES AND PROBLEMS

Municipal and Industrial Wastes

Organic pollution in this sub-basin arises primarily from municipal sources. There are 127,000 people presently being served by sewage collection systems. The waste from 43,000 people is discharged to the receiving streams after primary treatment while that from 93,600 receives secondary treatment. Collection systems serving about 400 people discharge without treatment to receiving streams. The remainder of the people of the hydrologic sub-basin, approximately 127,000, utilize on-site disposal, generally septic tanks. Total waste produced before treatment is 307,900 population equivalents. Total waste discharged after treatment is 87,000 population equivalents.

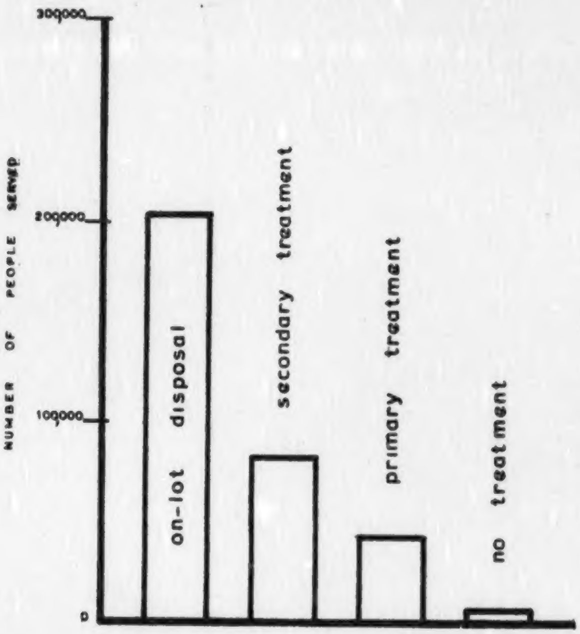
Three paper and pulp mills cause severe discoloration to the Little Juniata River and the Fransktown Branch. Although the wastes from all three plants receive secondary treatment, the organic loading discharged is high in relation to the size of these streams. Companies involved are

(1) D.M. Bare Dividion of Combined Mills at Roaring Spring (Frankstown Branch),

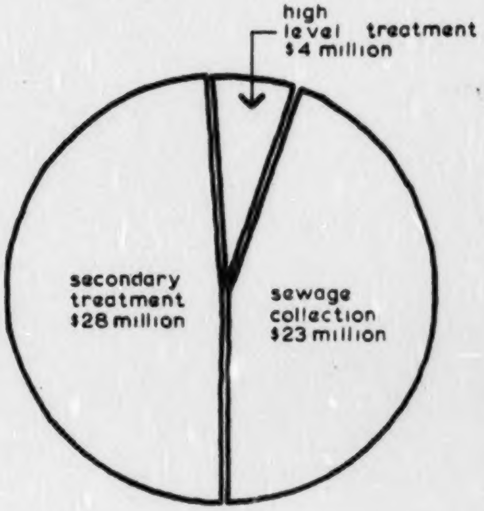
(2) Westvaco (two plants): at Tyrone (Little Juniata River) and Williamsburg (Frankstown Branch).

The wastes from these plants are treated at the local municipal treatment facility.

breakdown of treatment methods
(1968)



costs of recommended abatement measures (1965 - 1980)



ABATEMENT

Municipal and Industrial Wastes

All sewer service areas of this sub-basin should provide secondary treatment as a minimum. Thirteen of the 23 now provide less than secondary (see Immediate Needs Table).

About 127,000 people are now served by sanitary collection facilities. By 2020, it is estimated that this service will be increased so that approximately 455,000 will be served. Costs of collection facilities are projected as follows.

Time Period	Pop. Served (1000's)	New Pop. Served (1000's)	Estimated Cost ($ Millions)
1965	129.8	---	--
1965-1980	172.0	45.5	23
1980-2000	281.9	111.2	57
2000-2020	455.0	178.0	92

The following cost estimates reflect capital needs to achieve and maintain waste treatment at the secondary level.

Time Period	Pop.	Pop. Equiv.	Estimated Capital Needs ($ Millions)
1965-1980	172.3	502.9	28
1980-2000	283.5	826.7	17
2000-2020	461.4	1194.8	38

The two sewer service areas in the city of Altoona will require a high level of BOD removal. The Southwest District should attain 95 percent removal of BOD in the immediate future. Three other service areas, Tyrone, Roaring Spring, and Williamsburg, should attain high level BOD removal plus color removal from pulp mill wastes.

The table below summarizes the total cost of recommended treatment facilities including high level BOD removal systems. Costs do not include collection facilities.

Total Cost of Recommended Treatment Facilities *

Time Period	Population Equivalents (1000's) Received	Population Equivalents (1000's) Discharged	Estimated Capital Needs ($ Millions)
1965-1980	503	51	32
1980-2000	827	77	18
2000-2020	1195	104	47

* Costs do not include nutrient removal.

Mine Drainage

Although mine drainage discharges are not a significant source of pollution throughout the sub-basin, they do cause locally severe water quality problems. Sources in the Glen White and Burgoon Run watersheds seriously degrade Mill Creek, a tributary of the Beaverdam Branch. Sources degrading Aughwick Creek are found primarily in the Roaring Run watershed and several small tributaries to the Raystown Branch are also polluted.

		Avg. Acid Contribution			
		Flow		Acid	Iron
Principal Rec. Stream	Source Watershed	mgd	cfs	Lb/Day	Lb/Day
Frankstown Br.	Beaverdam Br.	9.9	15.3	16,200	1,600
Aughwick Cr.	Roaring Run	0.5	0.8	2,200	100
Raystown Br.	Longs Run	2.9	4.5	6,900	300
	Six Mile Run	3.5	5.4	7,500	700
	Shoups Run	11.0	17.1	6,800	400
	Great Trough	2.8	4.3	800	50
JUNIATA TOTALS		30.6	47.4	49,400	3,150

ABATEMENT

Mine Drainage

The most feasible solution for control of pollution associated with mining activities includes a combination of physical preventive measures followed by chemical treatment of the acid discharges. Preventive measures include reconstructing stream channels, excavating and restoring subsided areas, covering refuse material, backfilling selected strip mine areas, and constructing surface water diversions at selected locations. Chemical treatment through lime neutralization is considered to be the most feasible means of removing the remaining acid loads.

Based on methods now known, including physical preventative measures and chemical treatment of acid discharges, the following estimates indicate costs of abatement by watersheds.

		Costs of Abatement		
Principal Rec. Stream	Source Watershed	First Cost $ Millions	Total Avg. Ann. Cost $ 1000's	Operation & Maint. $1000's
Frankstown Br.	Beaverdam Br.	5.24	231	518
Aughwick Cr.	Roaring Run	0.37	47	67
Raystown Br.	Longs Run	1.76	104	206
	Six Mile Run	2.59	141	290
	Shoups Run	5.30	207	512
	Great Trough	1.23	84	154
		16.49	814	1747

Treatment by lime neutralization is recommended for those discharges remaining after preventative measures have been installed. Lime neutralization was the method used for estimating costs, since it has been field proven and appears to be the least costly.

The following is a summary of lime neutralization treatment costs.

	Est. Average Acid Load		Est. Treatment Costs $ Millions	
Watershed	Acid Flow # 1 Day	Acid Flow After Prevent. # 1 Day	First	Annual
Beaverdam Br.	12,000	9,000	0.35	0.148
Roaring Run	1,200	900	0.02	0.042
Longs Run	4,000	3,000	0.25	0.103
Six Mile Run	5,000	3,700	0.39	0.022
Shoups Run	4,000	3,000	0.34	0.128
Great Trough	600	450	0.06	0.060

MISCELLANEOUS WATER

QUALITY PROBLEMS

SOURCES AND PROBLEMS

Nutrients

Nutrient enrichment is evident in the Beaverdam Branch caused by the waste loadings from Altoona, and in the Raystown Branch, caused by the wastes from Bedford and Everett. Nutrient enrichment from agricultural runoff is a minor problem, since about 91 percent of the sub-basin is either in forests or grassland farming.

Combined Sewers

Three streams in the sub-basin are subject to periodic degradation by the overflow of combined sewers: Beaverdam Branch from Altoona and Hollidaysburg, Raystown Branch from Everett and Saxton, and Aughwick Creek from Orbisonia.

Individual Waste Disposal Systems

There will be an increase in rural population in the sub-basin, but individual treatment system is projected to decrease. By 1980, rural population using septic tanks is expected to grow to 232,000; and by 2020 it will decrease to 210,000. Periodic failure of these septic systems could cause locally severe water quality problems.

Thermal Pollution

Thermal pollution is not now, nor is it expected to be a future problem in this sub-basin.

ABATEMENT

Nutrients

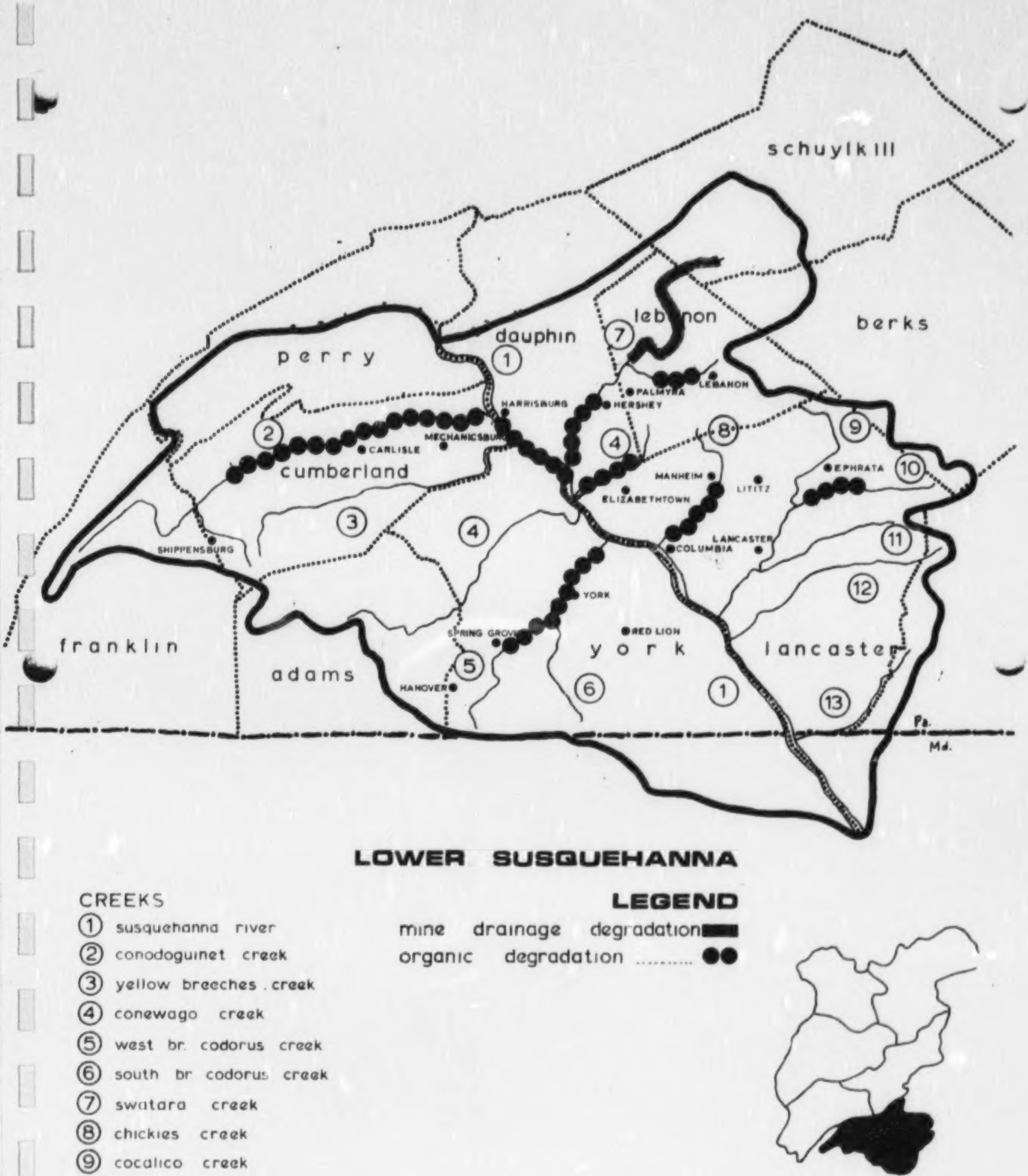
Although there are some indications that nutrients are causing the growth of algal blooms in the sub-basin, no specific abatement action to remove nutrients from waste water is recommended at this time. Study efforts should continue to determine levels of phosphorus and nitrogen and to identify stream reaches where these nutrients may be the cause of water quality degradation.

Combined Sewers

No economically feasible method is now available for eliminating the adverse effect of combined sewers. Extensive research is currently underway, but until a feasible alternative is found, it is assumed that existing combined sewers will continue to be used. It is recommended that no new combined sewers be built.

Individual Waste Disposal Systems

It may not be feasible for all rural populations to connect with regional collection facilities. Both New York and Pennsylvania administer laws regarding septic tank usage where tank capacity and drain field construction vary with soil type, lot size, and living-quarters capacity. These kinds of facilities can be very efficient when properly designed and maintained, but wherever possible, people are encouraged to connect into a regional collection system.



LOWER SUSQUEHANNA

CREEKS
① susquehanna river
② conodoguinet creek
③ yellow breeches . creek
④ conewago creek
⑤ west br. codorus creek
⑥ south br. codorus creek
⑦ swatara creek
⑧ chickies creek
⑨ cocalico creek
⑩ conestoga creek
⑪ mill creek
⑫ pequea creek
⑬ octoraro creek

LEGEND

mine drainage degradation ▬
organic degradation .... ●●

General Description

The watershed of the Lower Susquehanna is almost entirely within the Piedmont physiographic province and is characterized by low, rolling uplands and broad, limestone valleys. About 32 percent is in forest while much of the remainder is intensively farmed. The area contains some of the most productive agricultural counties in Pennsylvania: Lancaster, York, Lebanon, and Cumberland. The streams tend to be sluggish and filled with sediment and are less subject to drought than those in other parts of the basin. However, low flows sometimes do occur during the late summer and early fall.

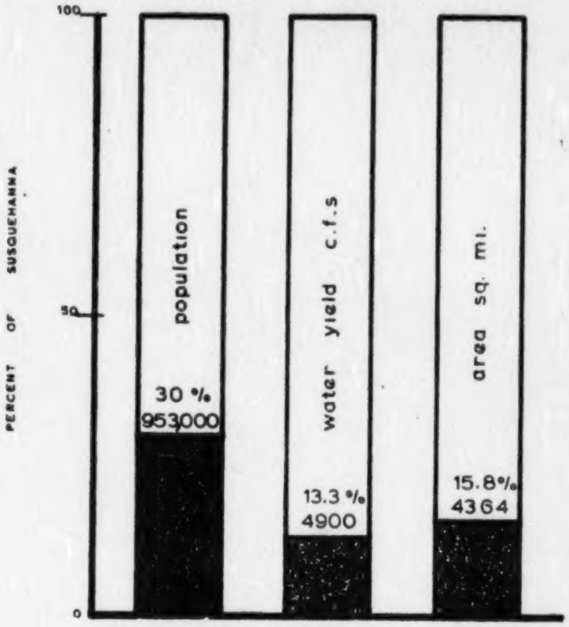
The area is prosperous and all but the headwaters of Swatara and Sherman Creeks are outside of the Appalachia poverty region. About 686,000 people live in communities served by municipal water systems.

The present population is about 30 percent of the basin's total. By 2020, the population is expected to grow to over three million.

For purposes of this study, the Lower Susquehanna was divided into 23 water service areas to determine current municipal and industrial uses and to predict future concentrated demands on the streams. It was divided into 39 sewer service areas to determine current waste handling and sewage treatment practices and to predict future organic waste handling needs. Evaluations were made to determine the effects on receiving streams caused by waste discharges from the sewer service areas.

Much of the Susquehanna's organic and nutrient load to the Chesapeake Bay comes from this area, and to remedy this about 11 sewer service areas will soon need to upgrade their waste handling facilities to secondary facilities; this is particularly necessary for communities along Swatara,

percent of total susquehanna basin



Conestoga, Codorus, and Conodoguinet Creeks. Many of these sewer service areas will also need to install some form of high level BOD and nutrient removal.

In addition, thermal pollution poses a threat to the lower portions of the river. Presently, three sizable power stations discharge heated water to the river without pre-cooling. In the near future, two of these will be phased out of continuous use, but two large atomic plants will come into operation and more than compensate for the power loss.

Mine drainage is not a big problem in the sub-basin except in the headwaters of Swatara Creek where about 17 square miles of land area have been disturbed by mining. The tributaries that arise in these areas bring about 15,000 lb/day of acid to the Swatara. This acid, however, is entirely neutralized before the Swatara joins the Susquehanna River.

An understanding of the surface and ground water resources is basic to effective water quality management programs. In general, the quantity and quality of the ground waters in the Lower Susquehanna sub-basin are adequate to meet the anticipated demands in certain portions of the area.

Waste assimilative capacities of the streams of the sub-basin are a function of flow and temperature during the critical summer season from July through October. Major tributaries of the sub-basin, shown in the following table, exhibit wide fluctuations of stream flow and clearly indicate the effects of drought conditions during the summertime on dependable stream flow which must be considered in delineating water quality management programs for the water service areas of the sub-basin.

Stream Flow Characteristics at Selected Locations

Stream and Gauge*	Instantaneous Flow Extreme Max.	Min.	Mean An. Flow	August Flow Data Mean Flow	1-in-20-yr. Low Flow	Minimum Daily Flow
Conodoguinet Cr. near Hogestown	13,100	24	556	320	102	87
Swatara Cr. at Harper	25,300	6.0	553	249	38	25
West Conewago near Manchester	47,600	1.9	550	276	21	13
Codorus Creek near York	7,770	3.5	227	108	19	13
Conestoga at Lancaster	22,800	0	371	234	46	30
Susquehanna River at Marietta, Pa.	787,000	618	35,110	11,674	4,900	4,532

---

* Data collected by U. S. Geological Survey (all measurements are stated in cfs.)

There are a number of man-made lakes in this sub-basin, most of which impound good quality water. The principal ones are listed below:

Lake or Park	County	Surface Area Acres	Quality Description
Memorial Lake	Lebanon	100	Good
Pinehot Park	York	340	Some nutrient and algae problems
West Codorus Park	York	1275	Good
Swatara (Inwood) (proposed)	Lebanon	600	Anticipated to be slightly acid
Safe Harbor	Lancaster-York	7330	Generally good but with some thermal, nutrient, and algae problems
Holtwood	Lancaster-York	2400	Generally good but with some thermal, nutrient, and algae problems
Conowingo	Cecil-Harford, Maryland	8560	Generally good but with some thermal, nutrient, and algae problems

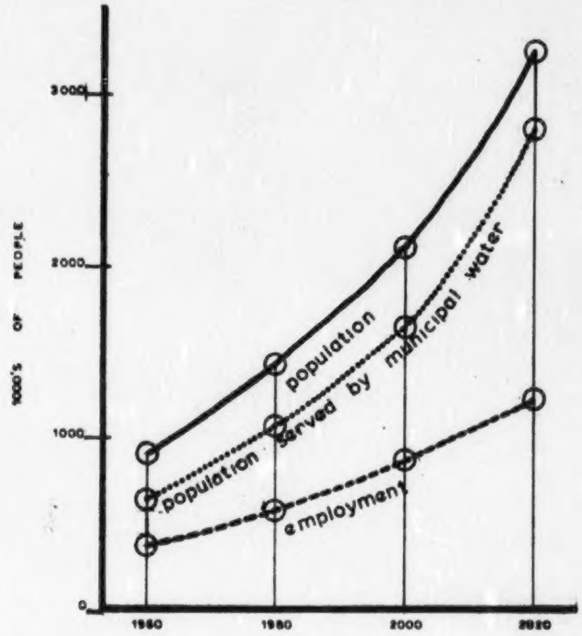
Economic Base

The Lower Susquehanna economic subregion includes Cumberland, Dauphin, Lancaster, Lebanon, and York counties of Pennsylvania and is the most densely populated of the basin with about 28 percent of the total in 1960. The population is forecast to expand by about 78 percent between 1960 and 1990 and by about 245 percent between 1960 and 2020. This rate of growth exceeds national and Susquehanna Basin rates for the same period. There are many towns and cities within the subregion but the highly urbanized areas are concentrated around major cities of Harrisburg, Carlisle, York, Lebanon, and Lancaster. Much of the projected population growth will be affiliated with these population centers.

Manufacturing in 1960 accounted for approximately 36 percent of total civilian employment; this was about the same as that for the Susquehanna Basin but higher than that for the nation. Because of the slow growth projected for manufacturing employment, about 13 percent between 1960 and 1990 and about 24 percent between 1960 and 2020, this area will experience a relative decline in importance when compared with the nation and with the whole basin. For this subregion, it will be less than 14 percent in 2020; in the Susquehanna Basin as a whole, 16 percent; and 18 percent in the nation.

The region has a highly diversified industrial base. Only two industries, apparel and food, accounted for more than ten percent of total manufacturing employment in 1960. The nearness of large markets, as well as the high population density and good transportation are some of the factors that will influence growth. Transportation equipment, ordnance,

population & employment trends



printing and publishing, and fabricated metals are projected to be rapid-growth industries. Employment in the transportation equipment industry is projected to grow faster than in the rest of the basin. Most of the firms in printing and publishing market products and supply services outside the subregion. Employment and production is expected to expand in response to increases in activity outside the region, while the fabricated metals industry is highly diversified within itself representing one of the major locational advantages of the area. Textiles and apparel manufacturing will decline, but apparel will not fall as rapidly as textiles because of the Eastern markets.

Nonmanufacturing employment is projected to grow rapidly; by 2020 about 86 percent of total employment will originate in this sector. The services sector will account for more than half of the employment gains rising from 16 percent in 1960 to 44 percent in 2020. Construction, government, and retail trade will account for another third of the increase.

York and Lancaster counties contain the greatest concentration of productive agricultural activity within the basin. Dairy, poultry, and other livestock products are the most important agricultural products sold by commercial farms. Broilers are raised throughout the subregion, while fruits and nuts are important cash crops in Lancaster and York counties. Lancaster County is also one of the leading counties in the nation in production of dairy products. Employment in agriculture will go from six percent in 1960 to two percent in 2020.

Mining is relatively unimportant in the region and employment is projected to decrease over the 1960-1990 period; its relative importance therefore is expected to diminish. Mining production includes sand and gravel, limestone, clay, and some iron ore.

In 1960, per capita income was about 2,300 dollars; it is expected to grow to 5,100 by 1990 and to 10,800 by 2020. The historical and projected per capita income levels are greater than those for the Susquehanna Basin and the nation.

The major water using industries provided about 11 percent of total employment in 1960. The number of jobs is expected to decline by 1990 but this is due primarily to the expected precipitous decrease in textile employment. Although the output of the petroleum industry is forecast to expand rapidly by 1990, employment in this sector, is and will continue to be, comparatively unimportant.

The following table gives the percent change in total output from 1960 to 1990 for the large water using industries.

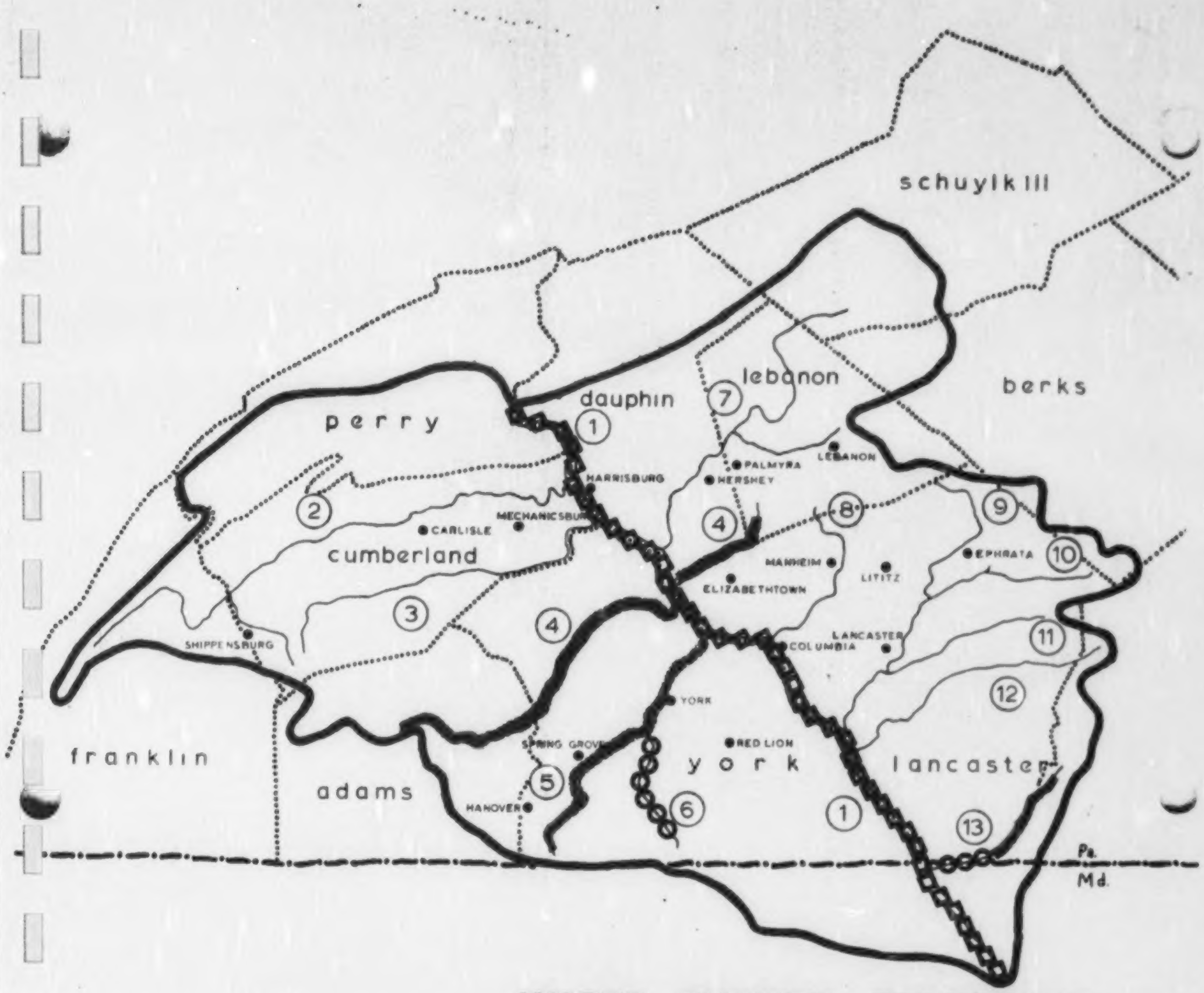
Projected Growth in Output for Major Water Using Industries
(in percent)

	1960 to 1970	1960 to 1980	1960 to 1990
Food	62	145	265
Textiles	28	30	44
Paper	53	95	145
Chemicals	94	243	508
Petroleum	255	651	1387
Primary Metals	30	76	146

Population and industrial growth projections as summarized above were used to project future waste loadings for the Lower Susquehanna sub-basin.

WATER QUALITY MANAGEMENT OBJECTIVES

Water Quality Standards and Present and Future Uses of Water



WATER QUALITY STANDARDS

LEGEND

cold water fishery ▬

warm water fishery ▬

public water supply ○○○

outdoor recreation □□□

CREEKS

① susquehanna river
② conodoguinet creek
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⑪ mill creek
⑫ pequea creek
⑬ octoraro creek

Water Quality Standards

Standards for the interstate streams in the Lower Susquehanna sub-basin have been adopted by the States of Maryland and Pennsylvania and approved by the Department of the Interior.

The waters in this sub-basin are intensely used. Compared to the other sub-basins, there are more demands for electric-power generation, industrial cooling, for municipal needs, and for water-based recreation. The water quality standards here reflect these diversified uses.

All Maryland portions of interstate streams in the Susquehanna are classified for public water supplies, recreation, swimming and aquatic life. The river in Pennsylvania is classified to protect a warm water fishery, boating, and general recreation. All waste discharges are required to maintain a level of secondary treatment. Both states restrict heated wastes discharges so that no legitimate use is impaired. A maximum of 5 F heat rise below the mix zone is allowed. In Pennsylvania the maximum temperature allowed, after mixing is 87 F while Maryland permits a maximum of 93 F.

Recreational Uses

Recreation is a major water use consideration in this sub-basin because of the large and affluent urban population both within the sub-basin itself and in nearby Maryland. The market population exerting demands upon the water here stands at 1.2 million people, which is 100,000 more than the population in residence. This population concentration makes it difficult to keep up with the public demand for opportunities in water-contact recreation. There are about 345 miles of streams and 84,050 acres of lakes accessible for recreation purposes.

While future population growth will double, future demands for recreational opportunities are expected to triple; and the deficit in water oriented recreation days will increase six-fold.

Future Recreation Uses

Target Year	Rec. Market Area Pop. (1000's)	Demand*		Supply*		Deficit in Water-Oriented Recreation
		Rec.	Boating	Rec.	Boating	
1980	1709	14.40	2.48	8.67	2.09	5.73
2000	2410	27.45	4.27	9.58	2.84	17.77
2020	3500	45.41	6.90	11.73	3.66	33.68

* Million days per year.

There are about 125,200 fishermen who use the waters of this sub-basin at a rate of 2.2 million user-days per year. They represent an estimated 10.6 million dollars of income to the area for such items and services as bait, supplies, and transportation. Most of the fishing effort is exerted on the 41,000 acres of warm water fisheries, primarily the Susquehanna River itself. There are however about 115,000 user-days spent on cold water fisheries, primarily trout waters; there are 407 miles of trout waters in the sub-basin. At present, this quantity of water area seems to satisfy the demands, but in the future the demand is expected to outstrip supply.

Year	Fishermen (1000's)	Fisherman Days/Yr. (Millions)	Annual Expenditures ($ Million)
1980	215.3	4.13	18.3
2000	328.5	6.37	28.2
2020	433.8	7.81	38.1

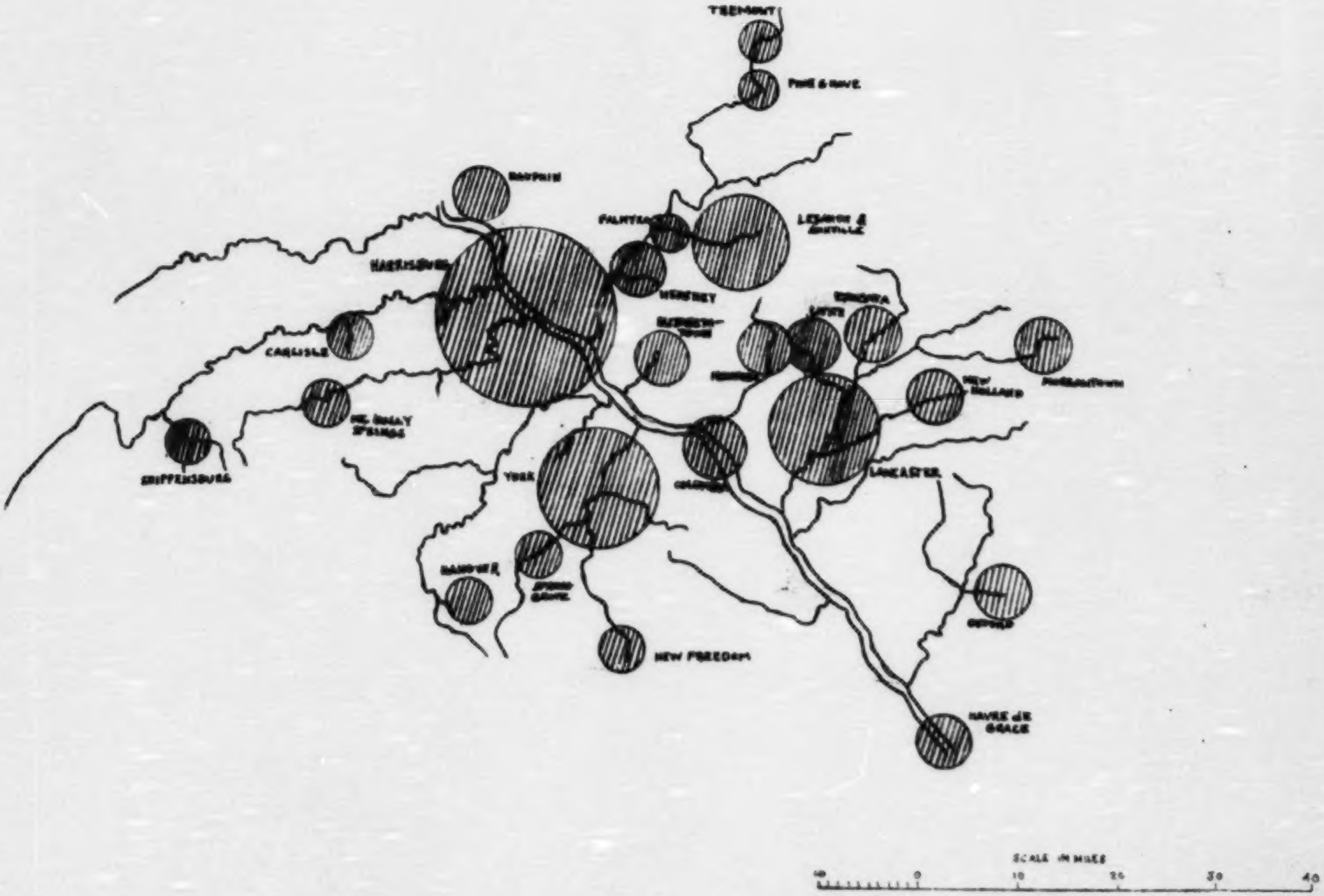
Municipal and Industrial Uses

The municipal and industrial demands are met by 23 principal water service areas which supply water to about 685,000 people. Total demand is 156 million gallons per day on the water supplies of the sub-basin. In addition, there are three large diversions from the sub-basin: Havre de Grace and Baltimore, Maryland, and Chester, Pennsylvania. The former two divert to the Chesapeake Bay, while Chester, Pennsylvania, diverts to the Delaware Basin. Havre de Grace requires about 1.1 million gallons, Baltimore 50 million gallons, and Chester 30 million gallons per day. Within 15 years, Havre de Grace will increase its demand to 1.9 million, and by 2020 to 5.7 million. By 1980, Baltimore is expected to increase its demand to 250 million gallons per day; by the year 2000 to 400 mgd, and by 2020 to 600 mgd.

Chester will increase its demand to 45 million gallons per day within 12 years and to 100 million gallons per day by the year 2020. Thirty million gallons of this will be diverted daily from Octoraro Creek, leaving a demand of 70 million from the Susquehanna to be supplied from the river above the Conowingo Dam.

Another diversion demand may be exerted by the proposed Mason-Dixon Authority. This authority is being created to provide water for the Philadelphia suburbs lying between the basin and the city of Philadelphia.

LOWER SUSQUEHANNA
WATER SERVICE AREAS



The requirement is expected to be about 120 mgd by 2020, and the source will also be the Susquehanna River above Conowingo.

In addition to these diversions, Harrisburg, Columbia, and Lancaster water service areas use the river as a source of public supplies.

Projected Municipal and Industrial Needs

Year	Pop. Served (1000's)	Municipal*	Industrial*	Total*
Present	685.5	67.1	88.4	155.5
2000	1087.8	125.1	161.2	286.3
2020	2769.9	430.1	372.7	802.7

* mgd

In general, the population of the sub-basin is expected to increase four-fold while municipal demands increase by a factor of six. Industrial demands will increase by four and combining these with other demands the total demand by the year 2020 is expected to be about five times greater than it is at present.

Irrigation Uses

Irrigation exerts a significant demand for water and is expected to increase more rapidly than in the other sub-basins. The source is primarily surface waters, and during drought years about 13,450 acre-feet are applied to about 8200 acres of croplands. To irrigate croplands during drought years through the year 2020, water consumption is expected to increase a little less than four-fold.

Competition for surface water in the Conodoguinet, Conestoga, and Conewago watersheds, especially during drought years, is expected to be critical. The major confrontation will develop between public supply demands for Lancaster and Carlisle and irrigation demands from Conestoga and Conodoguinet Creeks, respectively. Lancaster may have to resort entirely to the Susquehanna River to meet its increased demands. A similar competition will likely develop along the Conodoguinet where the needs for Carlisle and irrigation will exceed total supply during low flow periods. A problem is also foreseen in the Conewago watershed: orchard growers here will require more surface water than is available; therefore, extensive use will have to be made of ground water supplies.

In addition to the lands to be irrigated with water from surface sources, projections for the future indicate that many acres will also be irrigated from ground water supplies.

Projected Irrigation Needs

Year	Est. Acres Irrigated	Consumption (Acre-Ft.)	Estimated Maximum Instantaneous Demand (cfs)
Present	8,200	13,450	98
1980	14,300	23,890	170
2000	21,600	36,110	250
2020	28,300	47,260	328

Cooling Water Uses

Electric power is generated by four thermal plants and five hydroelectric plants; one of the thermal plants is an atomic facility located at Peach Bottom in Pennsylvania. All thermal plants use water from the Susquehanna River for their once-through condenser cooling systems. The conventional steam plants have an installed capacity of 17,034 MW of electric power, while the hydro facilities are capable of 870 MW at peak production. In addition, 800 MW can be generated for short periods by the Philadelphia Electric Company's pumped storage facility at Muddy Run.

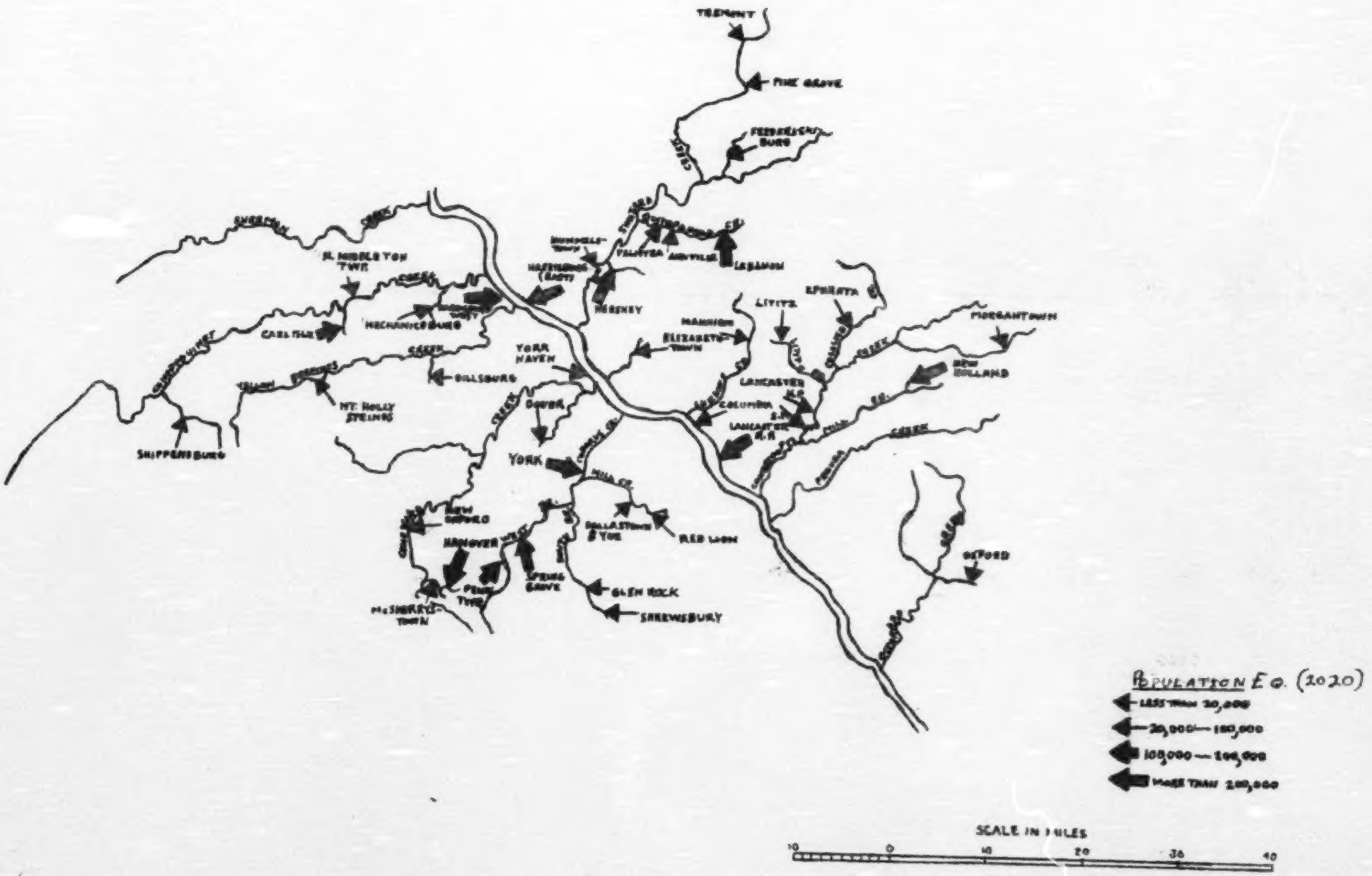
There is usually enough water to run the hydro-electric facilities at partial capacity even during low flow periods.

The Holtwood and Safe Harbor hydro facilities will be expanded during the 1970's. The flow required to generate maximum capacity of each will be 82,000 cfs, which is about the same at Conowingo's present flow requirements. Preliminary planning for a pumped storage hydro facility at Stoney Creek, near Harrisburg, has been completed, and it is anticipated to have an installed capacity of 1,000 MW.

Two atomic thermal plants are planned for the lower Susquehanna River. The Three Mile Island Plant at Middletown will have an installed capacity by 1980 of 1680 MW. The total cooling requirements will be 2,000 cfs which will be force cooled before discharge. It will use cooling towers with a requirement of 3700 cfs. This plant will have a designed capacity of 2200 MW, and will require 3700 cfs for condenser cooling which will be force cooled before discharge.

SOURCES, PROBLEMS
AND
POLLUTION ABATEMENT

LOWER SUSQUEHANNA
WASTE DISCHARGES



Sources of pollution and the associated problems have resulted in recommendation of abatement actions necessary. The table below summarizes the current conditions in the sewer service areas and identifies immediate pollution control program needs.

Sewer Service Areas and Immediate Needs Summary

Sewer Service Area	Present Capacity (mgd)	Present Treatment Level	Immediate Treatment Needs (Dec. 1968)	Maximum Allowable BOD Discharge
Shippensburg	1.6	Secondary	Advanced	140
Carlisle	3.0	Secondary	Advanced	2300
Hanover (incl. Utz Potato Chips)	2.2	Secondary	Advanced	600
McSherrystown	0.4	Secondary	Advanced	20
Penn Township	1.2	Secondary	Advanced	500
Spring Grove (incl. Glatfelter Pulp & Paper)	15.0	Secondary	Color Removal Advanced	1300
New Freedom	---	None	Advanced	170
Red Lion	0.8	Secondary	Advanced	80
Dallastown-Yoe	---	None	Advanced	260
York	18.0	Secondary	Advanced	2900
Tremont	---	None	Secondary	100
Pine Grove	0.3	Primary	Secondary	500
Fredericksburg	---	None	Advanced	70
Lebanon	6.5	Secondary	Advanced	1500
Annville	0.6	Secondary	Advanced	600
Hummelstown	---	None	Secondary	180
Elizabethtown	1.3	Intermediate	Advanced	900
Morgantown	---	None	Secondary	200
New Holland (incl. Zausner Cheese Factory)	0.9	Secondary	Advanced	1800
Harrisburg (East Shore)	26.8	Primary	Secondary	16000
Harrisburg (West Shore)	2.7	Primary	Secondary	13000*
York Haven	2.5	Primary	Secondary	2000*
Columbia	0.9	Primary	Secondary	15000

(Table continued on next page)

* Assuming temperatures of Safe Harbor Pool are not affected by thermal wastes.

Sewer Service Area	Present Capacity (mgd)	Present Treatment Level	Immediate Treatment Needs (Dec. 1968)	Maximum Allowable BOD Discharge
Oxford	0.3	Secondary		
North Middletownship	New	Secondary		
Mechanicsburg	1.2	Secondary		
Mt. Holly Springs	1.3	Secondary		
Dillsburg	0.3	Secondary		
New Oxford	0.2	Secondary		
Dover	0.2	Secondary		
Glen Rock	0.3	Secondary		
Palmyra	1.0	Secondary		
Hershey	2.0	Secondary		
Manheim	1.0	Secondary		
Ephrata	1.9	Secondary		
Lititz	1.2	Secondary		
Lancaster (North)	9.5	Secondary		
Lancaster (South)	6.0	Secondary		
Lancaster (river plant)	New	Secondary		

The following sections present an evaluation of sources, problems, and the necessary pollution abatement actions required to maintain water quality. These solutions are based upon the anticipated growth and development of the sub-basin.

SOURCES AND PROBLEMS

Municipal and Industrial Wastes

Organic pollution in this sub-basin arises from the numerous, large communities. Sewers presently serve nearly 490,000 people, about 275,000 of them connected to secondary treatment facilities. Collection facilities for nearly 210,000 citizens are connected to primary treatment plants, and 2200 people are served by collection facilities that discharge directly to the receiving streams without treatment. There are, however, another 1800 whose collection facilities are connected with tertiary treatment. The remaining 495,000 people in the hydrologic sub-basin use on-lot disposal systems.

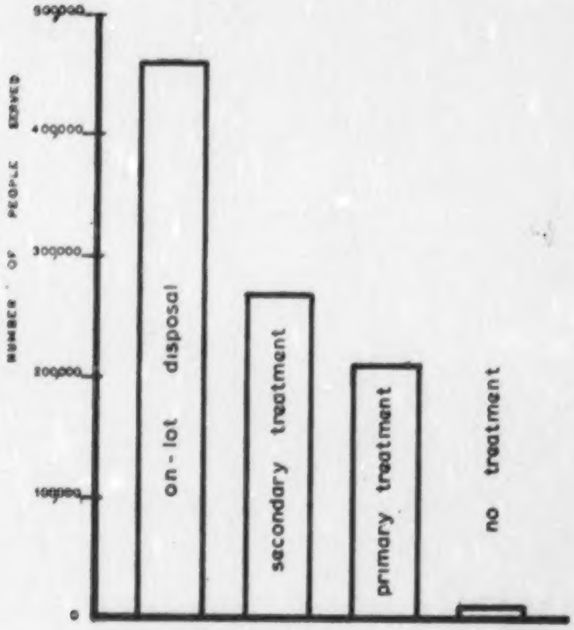
Total waste productions, including industrial amounts to 1,274,000 population equivalents, before treatment. Some 345,000 population equivalents are discharged after treatment, which is the same as 345,000 people emptying raw wastes into the receiving streams.

Industrial pollution arises from meat packing, chemical and paper pulping operations. Meat and food processing are major industries in the Lower Susquehanna, with ten operations in all. However, most food processors discharge to municipal sewer systems where they are located. A meat processing plant, the Grimes Poultry Processing Corporation located in Fredericksburg discharges waste materials into Deep Run. Another meat processor, the Bird-in-Hand Poultry Company uses Mill Creek as the receiving stream for its waste. Some of the other food and meat processors use leaching pits for waste disposal, but these may cause ground water to become degraded. However, there is presently no indication of detrimental affect upon either ground water or surface water.

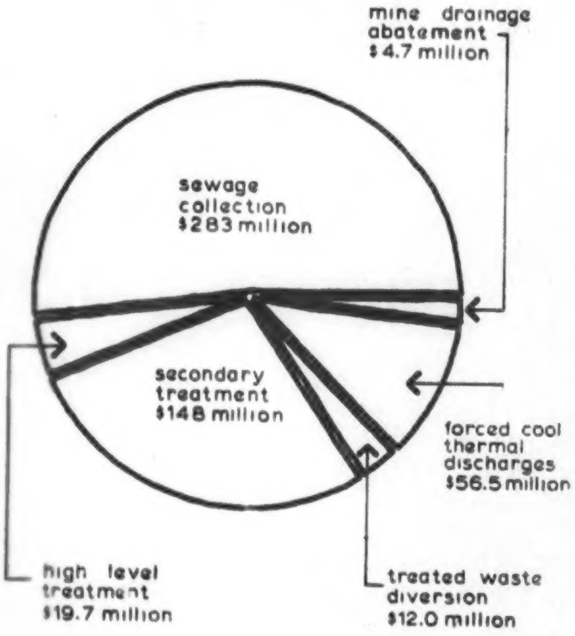
Neither the dairying operations nor the textile plants of the York and Lebanon areas cause pollution problems. The Lebanon Chemical Corporation manufactures pesticides and soil conditioners and the waste is discharged to the Lebanon sewage treatment plant which suffers overloading as a result.

The total population equivalents of waste from industrial sources in this sub-basin are 273,000 and the population equivalents remaining after treatment total nearly 81,000.

breakdown of treatment methods
(1968)



costs of recommended abatement measures (1965 - 1980)



ABATEMENT

Municipal and Industrial Wastes

All 39 sewer service areas should attain and maintain at secondary waste treatment as a minimum. Twenty-seven sewer service areas are already providing secondary treatment. Fifteen areas, including 11 which have secondary treatment now, should install high rate BOD removal systems in the immediate future (see immediate needs table).

Altogether, nearly 490,000 people are served by sanitary sewers, and this is projected to grow to over 2.7 million by 2020.

Projected Sewer Installation Cost Estimates *

Time Period	1000's Population Served	1000's of New Pop. Served	Est. Installation Cost $ Millions
1965	484.8		
1965-1980	985.8	501	283
1980-2000	1667.8	682	362
2000-2020	2770.8	1103	586

Cost projections for the attainment and maintenance of minimum secondary treatment in this sub-basin is as follows.

	1000's Pop. Served		Est. Capital Needs
Time Period	Pop.	Pop. Equiv.	$ Millions
1965-1980	1048	2481	148
1980-2000	1668	3804	26
2000-2020	2771	5656	127

* Costs do not include nutrient removal.

High level BOD removal or nutrient removal should be part of the pollution abatement program in 21 sewer service areas in seven watersheds of the Lower Susquehanna sub-basin.

Conodoguinet	Shippensburg
	Carlisle
	Mechanicsburg
Conewago	McSherrystonw
	Hanover*
Swatara	Fredericksburg
	Lebanon
	Annville
	Palmyra
Conoy	Elizabethtown
Conestoga	Lancaster (2 sewage service areas)
	Ephrata
	Lititz
	New Holland
Octoraro	Oxford
Susquehanna main stem	East and West Shores of Harrisburg
	York Haven
	Columbia
Codorus	Penn Township
	Spring Grove*
	York*
	Red Lion
	Dallastown
	Shrewsburg
	Glen Rock

* Places where treated waste diversion is a possibility.

Projected Costs for Advanced Waste Treatment

Time Period	Pop. Equiv. (1000's)	Est. Capital Needs ($ Millions)	Est. Avg. Ann. Expenses O & M ($1000's)	Est. Avg. Ann. Expenses Total* ($1000's)
Present-1980	1508	19.7	965	2124
1980-2000	2300	17.9	1348	3816
2000-2020	2853	43.1	1836	5067

* Includes amortization of capital at four percent for 20 years.

Diversion of treated wastes should be an immediate consideration for York and Spring Grove in the Codorus watershed and should be considered as a project within the next decade for Hanover in the Conewago basin and for Fredericksburg in the Swatara watershed. Eighty-five percent removal of BOD is the treatment level required. In the future, nutrient removal may also be a necessity.

Cost Comparison Between Diversion and High Level BOD Removal
York, Spring Grove, and Hanover

	High Level BOD Removal		Waste Diversion Pipeline	
Time Period	Est.Cap.Needs ($ Millions)	Total Est.Avg. Ann. Expense	Est.Avg.Needs ($ Millions)	Total An.Exp. ($1000's)
Present-1980	12.0	1278	19	985
1980-2000	12.6	2224	0.85	1125
2000-2020	13.0	1446	24.9	2483

Waste diversions can result in low flows in the reach which is being by passed. In Codorus Creek, during low flow conditions, all but 2.4 mgd is stored by the P. H. Glatfelter Company and all but 3.8 mgd in the south and east branches of the Codorus Creek is stored by the York Water Company. AS a result, only a small percentage of the total drainage basin contributes to stream flow. To restore the stream to its natural flows, it is suggested that Indian Rock Reservoir, designed for flood control, be converted to a multi-purpose reservoir and a portion of its storage by utilized for flow regulation to increase the low flows of Codorus Creek.

The study should be aimed towards investigating the potential of the reservoir to store water for recreation and low flow augmentation. The reservoir is presently used solely for flood control, and added uses may prove extremely beneficial.

Presented below are the cost of achieving water quality objectives based on treatment alone. The cost includes high level BOD removal, but do not include cost of collection facilities.

TOTAL COSTS OF RECOMMENDED TREATMENT AND
DIVERSION OF HEATED WASTES FROM THE YORK AREA

	1000's Pop. Equiv.		Estimated Capital Needs $ Millions
Time Period	Received	Discharged	
1965	1,274	345	---
1965-1980	2,481	370	184
1980-2000	3,804	562	34
2000-2020	5,656	778	172

Thermal Pollution

Currently, large quantities of heated wastes are discharged to the Susquehanna River near Middletown, York Haven, and Holtwood, from four major electric power generation plants. The plant near Middletown, called the Crawford Station, is owned by the Metropolitan Edison Company and requires 473 cfs of cooling water.

The Pennsylvania Power and Light Company owns and operates the Brunner Island Plant below York Haven on the Susquehanna River. This plant requires 1,100 cfs of cooling water. The Pennsylvania Power and Light Company also operates the Holtwood Plant near Holtwood, Pennsylvania, which requires 220 cfs of cooling water. It is expected that this plant will be phased out during the next ten to fifteen years.

There is presently one atomic plant, the Philadelphia Electric Company's Peach Bottom Atomic Plant and it requires 70 cfs of cooling water.

During periods of low flow, discharges from these thermal plants constitute a significant percentage of the river's flow. Combined with the anticipated increase in organic wastes, these heated discharges are expected to present great stress on efforts to maintain a 5.0 mg/l D.O. in the river. This is an especially great hazard below the Brunner Island electric facilities where during the summer of 1968, river water temperatures as high as 105 F were recorded below its mixing zone.

In the future, there will be two major atomic installations in this sub-basin. They will be located at Three Mile Island Plant near Middletown, Pennsylvania, and at Peach Bottom, just above the Maryland-Pennsylvania border. These will also use the Susquehanna River as a source of cooling water, but plans call for cooling towers to control heated discharge temperatures. The total cooling water required for the Peach Bottom plant will be about 3700 cfs.

Once these plants are installed, the total cooling water requirements for power generation below Harrisburg will be more than 6500 cfs. The largest concentration will be at Holtwood-Peach Bottom where 4200 cfs will be required. Flow in this section of the river often drops below 5,000 cfs.

ABATEMENT

Thermal Pollution

The degree of forced cooling which will be required depends on river flows and ambient river temperatures. An evaluation has been made of augmentation flows that would be needed to compensate for the once-in-20-year low flow situation where the temperature excesses would be severe. The evaluation considered three types of cooling systems: (1) run of river; (2) minimum forced cooling to meet state temperature standards for the low flow situations; and (3) closed cooling systems with no discharges to the river. The objective would be to maintain the 5.0 mg/l oxygen concentration under the conditions of the projected waste loadings. The Columbia-Lancaster area is expected to increase from its present 13,000 population equivalents (after secondary treatment) to 63,000 population equivalents in 2000 and to 116,000 population equivalents in the year 2020. If the temperature were increased from 77 F to 95 F and secondary treatment prevailed, the amount of water needed to assimilate the BOD and to maintain the 5.0 mg/l oxygen objective would be approximately seven times greater than the amount of water required at 77 F. If high rate BOD removal methods were used, the amount of water required to compensate for the same increase in temperature would be only five times greater.

With forced cooling system required, the optimum cost of maintaining standards depends on a comparison between cooling treatment and flow regulation costs.

The optimum alternative solution is probably a mix among the three variables. The difference between minimum forced cooling and closed cooling systems is estimated at 3.3 million dollars annually.

The minimum forced cooling systems are based upon designs to satisfy water quality standardx through the year 2020. The annual cost differences between secondary treatment (85 percent) and high level BOD (95 percent) removal for discharges directly to the river is estimated at 965,000 dollars annually.

Studies should be worked into the Susquehanna River Basin Coordinating Committee chaired by the Corps of Engineers. The studies should seek the optimum mix of high level BOD removal, forced cooling of thermal discharges, and low flow augmentation to maintain standards.

MISCELLANEOUS WATER
QUALITY PROBLEMS

SOURCES AND PROBLEMS

Nutrients

Waste loadings or farm runoff are causing serious nutrient enrichment in the Conodoguinet, Yellow Breeches, Conewago, Codorus, Swatara, Conoy, Conestoga, and Pequea Creeks. The nutrient enrichment of the tributary streams and the waste loadings from Harrisburg and York Haven are causing excessive algal growths in the Lower Susquehanna River. This is serious because it could lead to excessive algal growths in the river below Columbia and the Chesapeake Bay. During the summer of 1968, phosphate concentrations as high as 0.6 mg/l were recorded in the lakes.

This is the most intensively farmed land in the basin and, as a result, heavy nutrient concentrations attributable to agricultural operations have been recorded in the Conestoga, Pequea, Conodoguinet, and Conewago Creek watersheds.

Combined Sewers

Harrisburg, Lancaster, and York are served by combined sewers. Harrisburg presently releases about 163,000 population equivalents through its combined system to the Susquehanna River.

Lancaster uses Conestoga Creek as a receiving stream for its 142,000 population equivalents of combined wastes and York presently discharges 188,000 population equivalents to Codorus Creek during heavy storm flows.

Mind Drainage

Mine drainage pollution is evident in the upper portion of Swatara watershed, specifically Good Spring Creek and Middle Creek. These are both located upstream from the town of Tremont, Pennsylvania, and contribute about 15,000 pounds of acid per day to Swatara Creek flow.

Individual Waste Disposal Systems

There are presently 468,000 people using on-lot waste disposal systems. In 1980 this figure will decrease to 374,999 but by 2020 it will increase to 495,000.

ABATEMENT

Nutrients

Nutrient removal is recommended for the following sewer service areas:

- Carlisle
- Shippensburg
- Mechanicsburg
- Harrisburg (West Shore)
- Hanover
- Spring Grove
- York
- Oxford
- Lebanon
- Hershey
- Harrisburg
- Middletown
- York Haven
- Lancaster
- Lititz

More intensive efforts should be made towards installing land conservation practices with an aim towards reducing runoff.

Combined Sewers

Numerous methods of elimination of the adverse effects of combined sewer discharges are currently under intensive study, but at the present no economically feasible method is available for abating the pollution from this source. Unitl a practical solution is found, it is assumed that existing combined sewers will continue to be used. The Pennsylvania Sanitary Water Board has required that a separate sewer system in all future developments be installed. It is recommended that no new combined sewers be built.

Mine Drainage

The costs for both chemical and preventive treatment of mine drainage in this sub-basin is 4.69 million dollars at the outset, with the total annual average cost thereafter of 733,000 dollars. Resulting operation and maintenance costs are estimated at 460,000 dollars.

Recommended preventive measures include:

1. Removing acid producing refuse
2. Reconstructing stream channels
3. Constructing of surface water diversions
4. Covering refuse areas

As in the other sub-basins, treatment cost estimates were based on lime neutralization.

Individual Waste Disposal Systems

It may not be feasible for all rural populations to connect with regional collection facilities. Pennsylvania administers laws regarding septic tank usage where tank capacity and drain field construction very with soil type, lot size, and living-quarters capacity. These kinds of facilities can be very efficient when properly designed and maintained, but wherever possible, people are encouraged to connect into a regional collection sytem.

Octoraro Impoundment

The Octoraro Creek, above and below the Maryland-Pennsylvania border has shown signs of serious degradation during the summers of 1966-1968. This is almost entirely attributable to the quantity and quality of water being discharged from the Chester Water Authority Dam near Oxford, Pennsylvania.

Water is supposed to be released from this reservoir at the continuous rate of 28 cfs, according to the permit issued by the Pennsylvania Power and Water Resources Board. By the same permit, water diverted to Chester should not exceed 30 million gallons per day. However, these regulations are frequently violated, often because of water shortages at Chester. The lake becomes stratified in summer, and the releases made from its hypolimnion are low in dissolved oxygen and high in sediment content.

Up to 1969 there was no provision for treating backwash, which was discharged with high chlorine content directly to Octoraro Creek.

ABATEMENT

Octoraro Impoundment

Regulations of the Pennsylvania Power and Water Resources Board should be strictly adhered to, and a continuous recording gage should be installed immediately below the dam to record all flow releases.

The lake bottom should be dredged in the vicinity of the outlet to reduce sediment concentrations from releases of hypolimnion water. If this proves unsatisfactory, releases should be made from higher levels of the pool.

Lagoons should be constructed to settle out backwash materials and chlorine. Direct discharge of the chlorinated backwash should be stopped.